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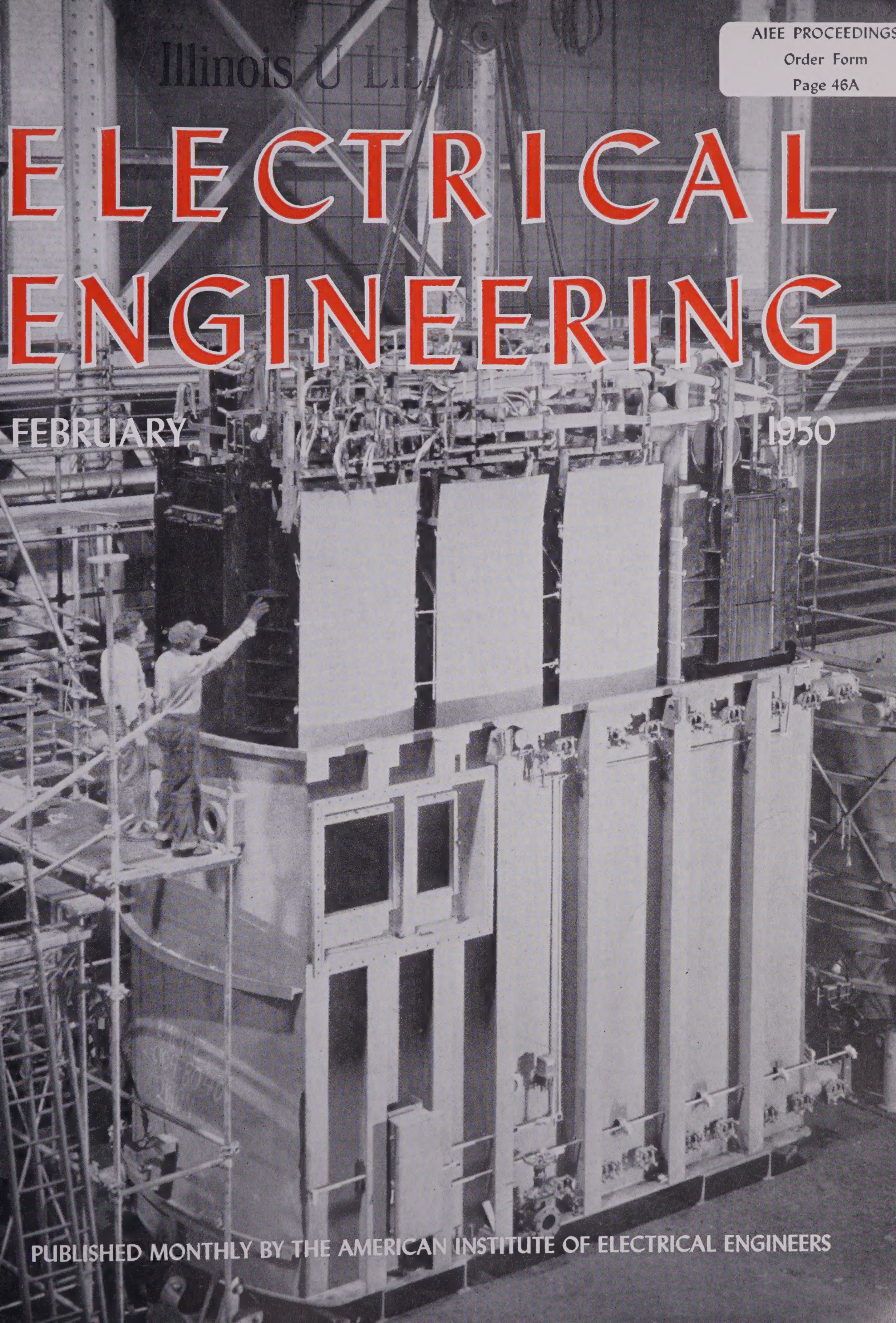
ELECTRICAL ENGINEERING

FEBRUARY 1950



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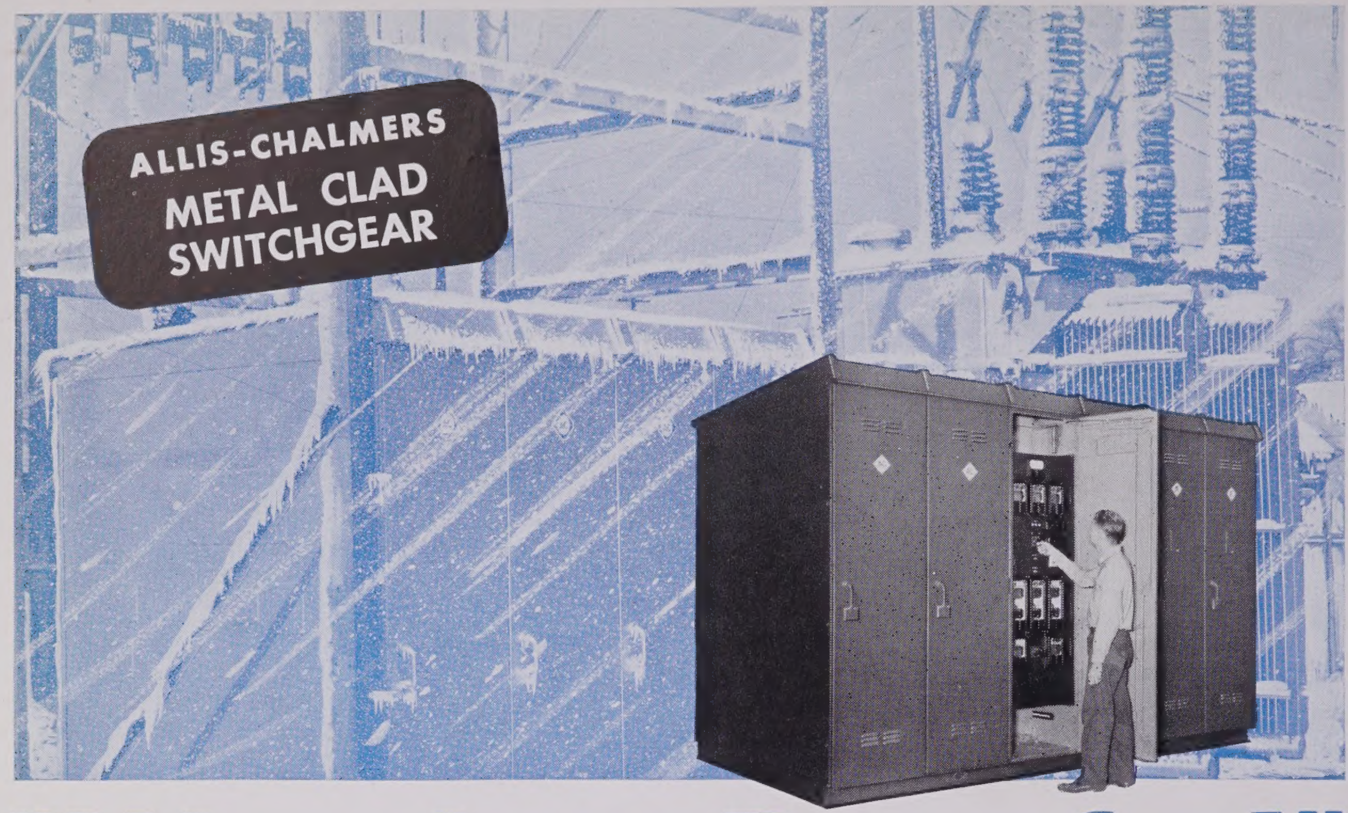

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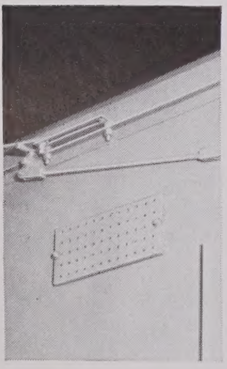

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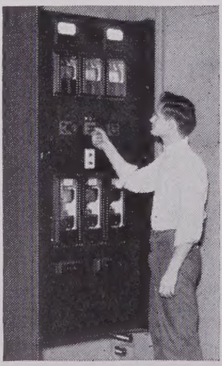

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The Cover: Lowering combination 3-phase transformer and autotransformer into its tank at the Allis-Chalmers Manufacturing Company's plant in Milwaukee, Wis. (see page 133).

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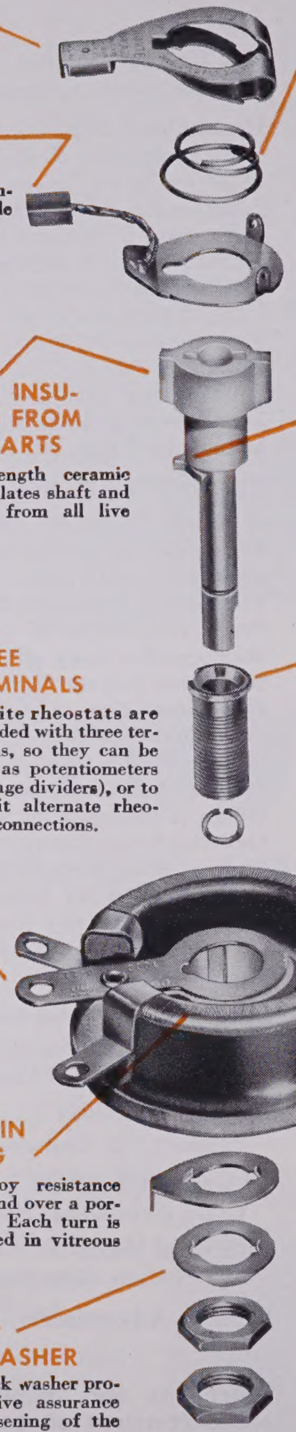

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HIGHLIGHTS........

Presidential Visits. Why didn't the President visit our Section? President Fairman answers the question by analyzing an Institute President's schedule for a year, thus showing why it is impossible for each of the 85 AIEE Sections to be visited every year (*pages 97–8*).

AIEE Proceedings. The latest listing of available AIEE *Proceedings* sections appears in the advertising pages of this issue (*pages 45A–46A*). This list gives technical papers included on the program for the AIEE Winter General Meeting, New York, N. Y., January 30–February 3, 1950. An index to all order forms for *Proceedings* sections now being honored appears elsewhere on this page.

The Engineer in Latin America. In the knowledge that many young engineering graduates turn to foreign fields, particularly Latin America, for career opportunities, this article attempts to answer some of the questions that a young engineer considering such a career would ask. Geographic characteristics, health conditions, educational facilities, clothing, opportunities, and educational requirements are touched upon (*pages 131–3*).

Engineering Curricula. Boundaries between college and secondary schools or trade schools are well defined, as are boundaries between post-high school technical institute training and engineering training at college level. However, confusion arises in varying degrees between engineering training and other college work, particularly in curricula which are in part engineering and in part other college subjects. A statement on "Differentiating Characteristics of an Engineering Curriculum" which has been adopted by the ECPD Committee on Engineering Schools is presented in this issue and comments are invited (*pages 99–101*). The latest listing of engineering curricula accredited by the ECPD has been issued; those institutions having electrical engineering curricula leading to a degree, or technical institutes which are accredited with curricula pertaining to electrical engineering or some phase thereof are listed herein (*pages 179–80*).

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Power Costs in Coal Mining. A study of the factors effecting power costs and trends in the coal mining industry are presented in this issue. The cost of electric power to the miner has decreased steadily; this decrease has been brought about by the increased use of power by mines which enables them to buy more power in the low-priced brackets. Power is now used to do many jobs which were formerly done by men or animals (*page 137–40*).

Sudden Load Reduction in a Steam Power Plant. What will happen in a steam generating station when it suddenly is generating ten times its load? A theoretical and practical study of this question has been made, and it has been found that the load can be maintained without damage to consumer or company property (*pages 101–06*).

Television Transmission Equipment. A new television transmitter has been designed by the Du Mont Laboratories. Having a visual output of 500 watts peak and an aural output of 250 watts, the transmitter may be used either as the basic unit of low-power local station or as standby equipment in a larger station (*pages 151–4*).

Techniques of Cable Accessory Design. New problems in design and construction of cable joints and potheads have been posed through the introduction of high-pressure cable systems and the use of higher voltages. New laboratory techniques have been developed to help the designer gain accurate information about these accessories for power transmission cable systems (*pages 119–24*).

Use of the Relay Digital Computer. The use of two Bell Laboratories large-scale digital computers is described this month. A discussion is presented of the process of setting up a problem, decisions which must be made by an attending mathematician and those decisions which can be left to the machine are noted. Samples of different types of problems which have been solved successfully by the machines are given and the procedures used are discussed (*pages 158–63*).

AIEE Proceedings

Order forms for current AIEE *Proceedings* have been published in *Electrical Engineering* as listed below. Each section of AIEE *Proceedings* contains the full, formal text of a technical program paper, including discussion, if any, as it will appear in the annual volume of AIEE *Transactions*.

AIEE *Proceedings* are an interim membership service, issued in accordance with the revised publication policy that became effective January 1947 (*EE, Dec '46, pp 567–8; Jan '47, pp 82–3*). They are available to AIEE Student members, Associates, Members, and Fellows only.

All technical papers issued as AIEE *Proceedings* will appear in *Electrical Engineering* in abbreviated form.

Location of Order Forms	Meetings Covered
Dec '48, p 35A	Midwest General Southern District
Apr '49, p 25A	Winter General (1949)
Jul '49, p 47A	South West District Summer General
Nov '49, p 51A	Pacific General Fall General
Feb '50, p 46A	Winter General (1950)

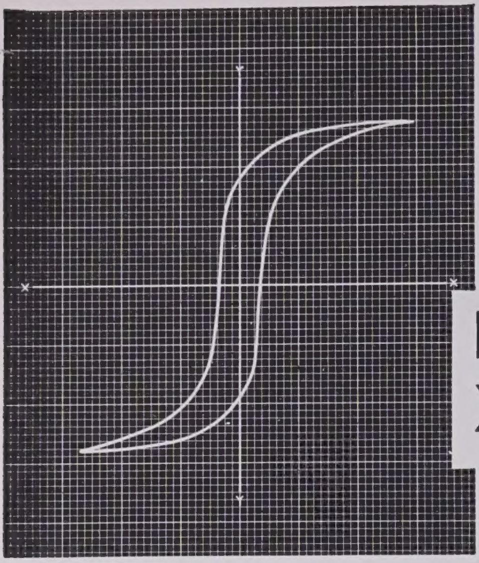
Television Terminals for Coaxial Systems. The *L-1* coaxial line is designed to transmit frequencies from 64 to 3,100 kc. The television band extends from a few cycles per second up to four megacycles, and these television signals are transmitted over the *L-1* line. It is the function of the television terminals to translate video signals into those which can be transmitted by the coaxial cable and to retranslate them into the proper video signals (*pages 109–15*).

Stackable Carrier Telephone System. The type-33 carrier system was designed to provide for the addition of three or less channels over existing circuits. These channels can be added one at a time as they are needed. The cost of installing the system is low enough so that it can be used on circuits ten miles long, but its gain is high enough to be used on long lines as well. Illustrations and descriptions of the components of the type-33 carrier system are given in this article (*pages 140–3*).

Out-of-Step Relay Equipment. Relays which will recognize an out-of-step condition in a system before the first slip cycle has been completed are now possible. In addition, for the first time the relative direction of the slip can be determined so that an out-of-step condition in a generator can be remedied easily (*pages 127–9*).

The Electric Eel's Discharge. The second in a series of articles on the nature of energy sources in animals considers the electric discharge of the eel (*pages 145–7*).

ELECTRICAL ENGINEERING. Published monthly by the American Institute of Electrical Engineers; publication office 20th & Northampton Streets, Easton, Pa. Editorial and advertising offices, 500 Fifth Avenue, New York 18, N. Y. Subscription $12 per year plus extra postage charge to all countries to which the special-class postage rate does not apply; single copy $1.50. Entered as second-class matter at the Post Office, Easton, Pa., under the Act of Congress of March 3, 1879. Accepted for mailing at special postage rates provided for in Section 538, P. L. & R. Act of February 28, 1925. February 1950, Vol. 69, No. 2. Number of copies of this issue 56,400



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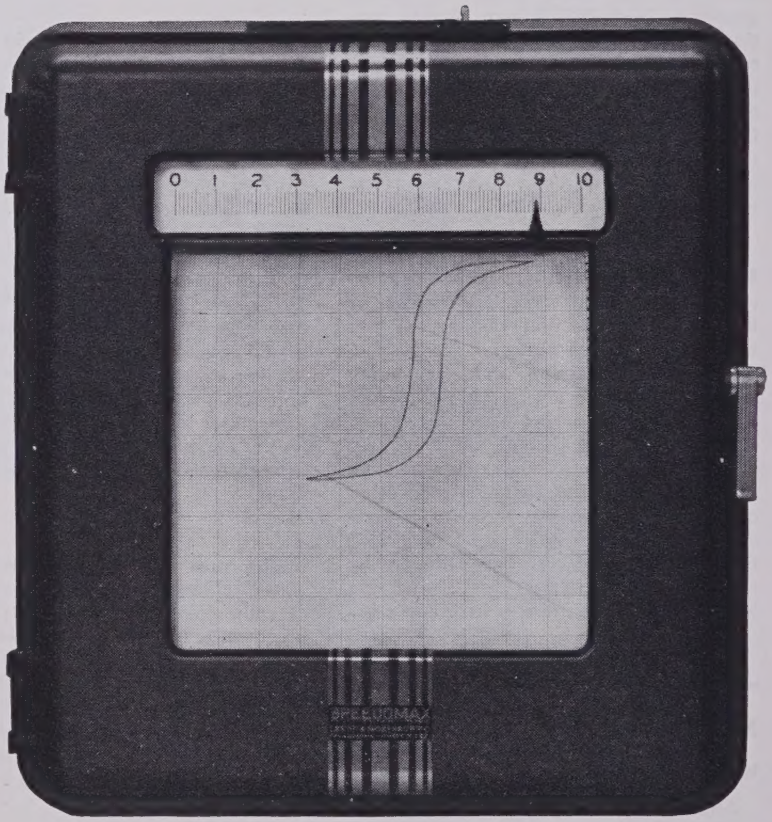

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Why Didn't the President Visit Our Section?

JAMES F. FAIRMAN
PRESIDENT AIEE

By analyzing the president's typical yearly schedule of Institute tours, AIEE President Fairman shows why it is impossible for every Section to be visited every year.

THE MOST ENJOYABLE part of being President of the Institute is the round of Section visits which is by tradition one of the President's duties. Everywhere he goes he is most cordially received. The hospitality of the Sections is apparently limited only by the adherence of the President to his schedule. He has the opportunity to meet old friends and to make new ones. He has the privilege of informing the members about the Institute's work and its problems. He gains new and broader viewpoints on the organization's activities and senses the needs and aspirations of the membership. He receives inspiration from the interest and enthusiasm of the Section officers. If he takes the relatively little additional time required to travel by automobile he sees the country at close range and enjoys Nature in all her moods. In a very real sense, his tours are the equivalent of a series of vacations.

THE PRESIDENT'S YEAR

It is regrettable that it is impossible for the President to visit every Section every year. This is due to a number of factors—the increasing number of Sections, the difficulty of arranging a schedule to meet the needs of individual Sections, the large part of the year in which no meetings are held, the attention which the President must give to other important Institute activities and the inescapable fact that he must try to hold the job which makes it possible for him to eat when he is at home.

A little simple arithmetic will illustrate the point. From the 365 days in the year, subtract the 104 Saturdays and Sundays which are not suitable for Section meetings, subtract the 66 working days during the months of June, July, and August (or from the latter part of May to the latter part of August) in which Section meetings are not usually held, subtract the 15 working days during Thanksgiving week and the two weeks around Christmas and New Years, and subtract the 15 working days for the Fall and Winter General meetings and the two District meetings usually held each year, and there are left a maximum of but 165 days which are theoretically available for Section visits.

There are practical difficulties in the way of using all these 165 days. Some allowance must be made for travel time. For good, local reasons some Sections have a continuing commitment for a definite meeting night or a strong preference for a particular night in each month or even for a particular night during the year. These considerations conflict with the laying out of a travel schedule to minimize the President's time away from home. It has not been possible this year to make five visits in five consecutive days. The maximum has been four visits in five consecutive working days and the average is closer to three. Three-fifths of 165 is 99. There are 85 Sections. The remaining 14 days would not suffice to take care of the President's other Institute obligations—to say nothing of his job. And note that no consideration has been given in these calculations to visiting any of the 129 Student Branches.

DIRECTORS' RESOLUTION

It was their increasing concern with this problem which led the Board of Directors in June 1947 to resolve (among other things) that:

(*a*). Attendance of the President at general meetings, District meetings, meetings of the Engineers' Joint Council, and other inter-society obligations should take precedence over visits to Sections.

(*b*). The District Vice-President shall be made fully responsible for the visits to local Sections. It shall be the duty of the District Vice-President to receive all requests for Institute officer speakers and to co-ordinate these requests for all meetings in his area. If the District Vice-President is not to make the visits personally, he may be free to arrange for other officers or members of the headquarters staff to be the official delegate when this appears to be the most effective.

and again in August 1948 to order that "a communication

James F. Fairman is Vice-President, Consolidated Edison Company of New York, Inc., New York, N. Y.

be sent to the Sections pointing out the fact that the Institute has grown to a point where it is no longer reasonable to expect the President to visit even half of the Sections, and suggesting that invitations to the President be discontinued and the Vice-Presidents invited to meetings in his place." As a result, the District Vice-Presidents met with the President-elect during the Summer General Meeting at Swampscott, Mass., in June 1949 and worked out a tentative schedule of Section visits built around the locations and dates of the four general and two District meetings to be held during this administrative year and based on the principle that each Section should be visited by the President once every three years, the converse of which is that the objective maximum number of visits each year would be one-third of the Sections, or approximately 28.

Table I. Schedule of Presidential Visits During 1949–1950

	S	M	T	W	T	F	S		S	M	T	W	T	F	S
AUG	7 ~~14~~ ~~21~~ ~~28~~	1 8 ~~15~~ ~~22~~ ▨29	2 9 ~~16~~ ☒23 ▨30	3 10 ~~17~~ ☒24 ▨31	4 11 ▨18 ☒25	5 12 ~~19~~ ☒26	6 ~~13~~ ~~20~~ ~~27~~	FEB	5 12 19 ~~26~~	6 13 20 ~~27~~	7 14 21 ▨28	☒1 8 15 22	☒2 9 ▨16 23	☒3 10 17 24	4 11 18 ~~25~~
SEPT	~~4~~ ~~11~~ 18 25	~~5~~ ~~12~~ 19 26	▨6 ▨13 20 27	▨7 ~~14~~ 21 28	~~1~~ ▨8 ~~15~~ 22 29	~~2~~ ~~9~~ 16 23 30	~~3~~ ~~10~~ 17 24	MAR	~~5~~ ~~12~~ 19 26	▨6 13 20 27	▨7 14 21 28	▨1 ~~8~~ 15 22 29	▨2 ▨9 16 23 30	~~3~~ ▨10 17 24 31	~~4~~ ~~11~~ 18 25
OCT	2 9 ~~16~~ ~~23~~ ~~30~~	3 10 ☒17 ▨24 31	4 11 ☒18 ▨25	5 12 ☒19 ▨26	6 ~~13~~ ☒20 ▨27	7 ▨14 ☒21 ~~28~~	1 8 ~~15~~ ~~22~~ ~~29~~	APR	2 9 16 23 ~~30~~	3 10 17 24	4 11 18 25	5 12 19 ☒26	6 13 20 ☒27	7 14 21 ☒28	1 8 15 22 ~~29~~
NOV	6 13 20 27	▨7 14 21 28	1 8 15 22 29	2 9 16 23 30	3 10 17 24	4 11 18 25	5 12 19 26	MAY	~~7~~ ~~14~~ 21 28	~~1~~ ~~8~~ ▨15 22 29	▨2 ~~9~~ ▨16 23 30	▨3 ~~10~~ ~~17~~ 24 31	▨4 ☒11 18 25	~~5~~ ☒12 19 26	~~6~~ ~~13~~ 20 27
DEC	~~4~~ ~~11~~ ~~18~~ 25	▨5 ▨12 19 26	~~6~~ ▨13 20 27	▨7 ▨14 21 28	~~1~~ ~~8~~ ▨15 22 29	▨2 ~~9~~ ~~16~~ 23 30	~~3~~ ~~10~~ ~~17~~ 24 31	JUNE	~~4~~ ~~11~~ ~~18~~ ~~25~~	~~5~~ ☒12 ~~19~~ 26	~~6~~ ☒13 ~~20~~ 27	~~7~~ ☒14 ~~21~~ 28	1 ~~8~~ ☒15 ~~22~~ 29	2 ~~9~~ ☒16 ~~23~~ 30	~~3~~ ~~10~~ ~~17~~ ~~24~~
JAN	1 8 15 22 29	2 ▨9 16 23 ☒30	3 10 17 24 ☒31	4 11 18 25	5 12 19 26	6 13 20 27	7 14 21 28	JULY	2 9 16 23 30	3 10 17 24 31	4 11 18 25	5 12 19 26	6 13 20 27	7 14 21 28	1 8 15 22 29

▨ SECTION OR STUDENT BRANCH MEETINGS (35 = 35 DAYS)
☒ GENERAL OR DISTRICT MEETINGS (6 = 24 DAYS)
— TRAVEL ASSOCIATED WITH MEETINGS (80 DAYS)
TOTAL DAYS AWAY FROM HOME = 139 DAYS OR 38% OF THE YEAR

Subsequently, by correspondence and with the wholehearted co-operation of the Sections, the schedule was modified as necessary to suit their requirements and the President's commitments. A few of the dates beyond the present writing are still tentative but the schedule shown in Table I is sufficiently accurate to illustrate what the President has done and will do this year.

The President didn't say "no" as firmly as he should have done in a few instances. Hence, he will have exceeded the figure of 28 by 25 per cent, not counting the six where he will have been present from two to five days in connection with general or District meetings. Actually, he will have officially visited in the territories of 41 Sections, but this is a substantially smaller number than can be credited to his predecessors in recent years.

Table I does not show the visits he has made on their invitation to meetings of other engineering societies. Nor does it show the five meetings of Engineers' Joint Council nor the monthly meetings of United Engineering Trustees. There is no practical way of showing or of measuring the time he spends at Institute headquarters or in his own office on Institute business but he hopes that he will be believed when he states that it is of the same order of magnitude as the time he spends on Institute business on the road.

This article is intended to be informative to the end that Section officers and District Vice-Presidents will continue to be as co-operative with future Presidents as they have been this year in making the schedule of presidential visits a pleasure rather than a burden, in making them an asset rather than a liability to the conduct of the affairs of the Institute. It is believed that a better understanding of the problem by the membership will assist in finding a solution which will be in the best interest of the organization.

Differentiating Characteristics of an Engineering Curriculum

S. C. HOLLISTER

This statement, prepared by Dean Hollister and adopted by the Committee on Engineering Schools of the Engineers' Council for Professional Development, was presented at the annual meeting of the ECPD in Chicago, Ill., October 29, 1949. It is followed by a discussion by Dean Hollister. Comments on this statement, particularly from engineers in industry, are invited.

THERE HAS BEEN a steady increase in specialized branches of engineering during recent years. Some of these are simply specializations in functional engineering, such as welding engineering, tool and die engineering, petroleum engineering, and refinery engineering. Others are associated more closely with the basic sciences, as, for example, geological engineering or engineering physics. Still others tend toward the border line of business, such as administrative engineering or general engineering.

Many engineering schools have catered to the popular demand for specialized training in a wide variety of engineering specialties. As a result there exists today some confusion as to what really characterizes an engineer, or indeed a curriculum suitable for training for any of the branches of engineering. It appears timely, therefore, to examine this situation and to prepare if possible a compact statement of what characterizes engineering training. In fact, if accreditation is to be successful, curricula so accredited must contain such characteristics as may readily identify them as engineering curricula.

BOUNDARIES BETWEEN ENGINEERING AND CONTIGUOUS FIELDS

Engineering education is surrounded by other educational operations. It will be helpful to explore the boundaries between engineering and those contiguous fields in order that a clearer understanding of engineering education may be had. It would be hoped that such a process of boundary exploration would eventually so circumscribe the training and function of the engineer as to make it feasible to undertake a direct definition of the characteristics of an engineer.

It is generally accepted that engineering training is at the college level. Thus one segment of its boundaries would be represented by the trade school, the technical institute, and the general secondary school. Within the collegiate area it is bounded by programs in the liberal arts, in science, in business, architecture, agriculture, and so forth.

Boundaries between college and secondary schools or trade schools are well defined. Similarly the technical institute operating at post high school level is readily distinguished from engineering training at college level. Confusion arises in varying degrees between engineering training and other college work. Particularly it arises in curricula which are in part engineering and in part other college subjects.

It should be stated clearly that this discussion does not undertake to evaluate curricula which are in part engineering and which are heavily charged with work in business, liberal arts, or some other field. Such courses are highly desirable and more of them should be given. The sole problem considered here is whether such curricula should be considered as engineering curricula leading to an engineering degree. This calls for a specification of differentiating characteristics contained in an engineering curriculum.

COMPARISON OF SCIENCE AND ENGINEERING CURRICULA

A comparative study of curricula in science programs with those in engineering reveals a significant difference between the two groups of curricula. It is characteristic of the engineering programs that mechanics, mechanics of materials, and courses in the properties of materials be included. Based upon such courses, it is also characteristic that in varying degrees there will be courses relating to structures, apparatus, or machines, and the principles upon which they are designed, constructed, and operated. Such courses are not found in the science curricula. For example, a curriculum in mining engineering will include mathematics, physics, chemistry, and geology, as will also a curriculum in geology. But the mining engineering curriculum also contains courses in mechanics, hydraulics, hydraulic machinery, heat engines, and electric equipment. The inference is that the mining engineer is going to design, construct, and operate and that the geologist is interested in the formation and nature of the earth's crust but that he is not intending to design, construct, or operate works either above or below ground.

When curricula in engineering and in architecture are compared, courses in mechanics and materials and sometimes in structural design are found in the architectural program. The principal characteristic of the architectural curriculum, however, is training to achieve artistic excellence in the proportions of parts and in the decorative treatment of structures. In practice the architect empha-

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sizes function and beauty, whereas the structural engineer emphasizes function and safety. The two fields obviously lie very close together and it is conceivable and, in fact, is occasionally true that the architect may act as a structural engineer, and vice versa.

A comparison of curricula in electrical engineering and in physics reveals the characteristic presence in the engineering curriculum of mechanics and materials of engineering. The physicist ascertains the behavior of physical phenomena in terms of physical principles and, generally speaking, is not concerned with design of machinery and apparatus for manufacturing purposes. The engineer, on the other hand, is applying the principles of physics in the creation of machinery and apparatus for manufacturing or other useful purposes.

DISTINGUISHING CHARACTERISTICS OF AN ENGINEERING CURRICULUM

Throughout these differences of characteristics noted between the engineer and a person in an adjoining field, one finds ability to design as a significant and distinctive element. The process of contriving a scheme, system, or concept of a device, together with a forecast of behavior thereof, which if built would be appropriate to the functional, economic, and safety requirements, is here meant as design. An engineer, for example, designs a bridge by first analyzing the conditions and functions to be satisfied; and secondly, by synthesizing from his knowledge of foundations, loadings, construction methods, mechanics, properties of materials, traffic requirements, economic considerations, financing, and so forth, the elements appropriate to this particular structure.

It may now be stated that:

An engineer is characterized by his ability to apply creatively scientific principles to design or develop structures, machines, apparatus, or manufacturing processes, or works utilizing them singly or in combination; or to construct or operate the same with full cognizance of their design, and of the limitations of behavior imposed by such design; or to forecast their behavior under specific operating conditions; all as respects an intended function, economics of operation, and safety to life and property.

The function of design is not limited to machines and structures. Process design may be defined briefly as the determination of the best process to accomplish a given end from the standpoint of economy, safety, and available raw materials and equipment. Courses in engineering application, therefore, which supplement those in applied science for full development of design qualifications are not limited to machine or structural design, but include production processes.

A curriculum which adequately trains a man to become an engineer must furnish the technical background, and should supply also the general training, for the process of analysis and synthesis essential to designing. There is the question, however, as to what may be considered an adequate training in the various essential features of the curriculum.

All engineering curricula may be divided into five sections as follows:

1. Basic science (mathematics, physics, chemistry, biology).
2. Applied science (mechanics, thermodynamics, fluid mechanics, aerodynamics, geology, properties of engineering materials, and so forth).
3. Applied engineering courses (as, for instance, internal combustion engines, machine design, structures, industrial electronics, plant layout, and so forth).
4. Administrative and managerial (cost control, quality control, industrial organization, labor relations, and so forth).
5. General (liberal courses designed to provide a general educational background).

Mathematics, physics, chemistry, and biology are the fields of basic science which form the foundation of engineering training, in amounts appropriate to the particular branch of engineering.

Whether administrative and managerial subjects or courses relating to general educational background are included in the curriculum is not essential to our present study because they do not contribute to those peculiar characteristics which differentiate the engineer from his layfellows. These do, however, contribute broadly to development of those qualities of professionalism which characterize the engineer capable of large engineering works, especially when such subjects are reinforced by broad attitudes and inspiration of the teaching staff.

Preparation for any form of design originates in the basic science courses, and is governed not alone by what science courses are included, but also by the depth of such courses and the extent to which they are interwoven into subsequent courses in applied science and engineering. For example, mechanics taught without calculus results in much less design ability than mechanics taught with calculus. Similarly, electrical theory taught without differential equations and Fourier's series develops much less power of analysis and synthesis than would have been the case had these two branches of mathematics been employed. The level of course content, and thus of training, is usually set by the depth of training in the basic sciences and what is equally important, the extent to which these permeate the subsequent courses.

Discussion

No attempt has been made to describe all of the functions that engineers may perform in the course of the practice of engineering. Instead, the differing characteristics have been sought, by which the engineer's work may be recognized from the work of others. A common definition of an engineer frequently quoted is that he is "one who directs the forces of nature to create useful things." Such a statement would not, for example, exclude the architect or the agriculturalist. Many of the engineer's functions overlap those of others, and thus are not in themselves distinctive characteristics of engineering. The engineer directs men; so do persons in many other professions and callings. He applies principles of economics and finance; so do businessmen and bankers. What is here sought is that characteristic which includes all kinds of engineering but which excludes all but engineering.

It is in part a characteristic of the engineer that he applies scientific principles in design, construction, and operation. This differentiates him from the artisan, who constructs or operates without scientific knowledge. The engineer, furthermore, constructs and operates within the framework of limitations inherent in the design; and to do such constructing and operating he must be fully conversant with the design and its limitations.

It is not an essential that in order to be an engineer one must be engaged in designing. It is essential that a knowledge of design be had, based on the application of scientific principles. Such design is not aimed primarily at aesthetic or functional objectives alone, but in addition characteristically includes objectives involving economics and safety. The economic objective in part distinguishes the work of the engineer from that of the scientist or the artist.

It is recognized that the words "design" and "designer" mean different things to different people. They are not here used in the narrow sense usually attached to them in engineering offices, where some are "designing," some "detailing," others "developing," and so on. The whole creative process, extending from the initial conceptual thought to the subsequently refined final plan, is here meant as design. It may be achieved by mathematical or developmental procedures, but it utilizes scientific principles.

There is real danger in undertaking to be specific as to the characteristics desirable in any professional program, because there is the possibility of too literal a translation of such a statement into courses rather than into guiding principles. The committee is fearful that the mention of "design" might suggest to some the thought that what is desired is a certain number of credit hours in one or more courses labeled "design." This is not what the committee has in mind. Rather, it hopes that "design" will be regarded in a broader and more fundamental way, involving the development within the student of original, resourceful, creative ability. Such an achievement results perhaps more from the nature of the teaching than from course outline. It becomes a way of education.

Sudden Load Reduction in a Steam Power Plant

JOHN G. NOEST
MEMBER AIEE

A sudden cut in load of a generating plant presents unusual conditions to operating personnel. In order to maintain service and assure the safety of equipment, a study was made of a station having only one tie feeder which carried most of the station's load.

With a generating capacity considerably in excess of its local busload, the Sherman Creek generating station of the New York Consolidated Edison Company has to depend on one high-capacity tie to connect it with the rest of the system. Use of the major portion of the plant's capacity, therefore, depends on this tie feeder to transmit all of the plant's output that is not needed for the local bus load. At certain times the plant generates ten times the local load.

Any weakness in this single link between the Sherman Creek station and the rest of the system exposes the plant to unusual operating conditions. A trip-out of the feeder will result in a sudden, severe unloading of the plant.

To discover whether or not a trip-out involved particular hazards to the continuity of service to the local consumer load and to plant equipment, as well as to formulate operating instructions for the guidance of the plant operating personnel, a study was undertaken to disclose the performance of the component parts of the plant when the plant was subjected to a sudden reduction of its load. This study was aimed particularly towards the determination of the performance of the local electric system, the turbine plant, and the steam generation equipment. This study was later expanded to include actual tests involving the dropping of various percentages of the plant generation; it includes the experience gained during unstaged, accidental trip-out of the tie feeder.

THE PLANT AND ITS INTERCONNECTIONS

Prior to 1943, when the first of two topping units was installed, the Sherman Creek station contained eight condensing turbogenerators varying in size from 15 to 30 megawatts with a total capacity of 171 megawatts. The steam generating equipment consisted of 50 boilers which were originally provided with stokers. Some of these were later converted to oil. The steam pressure was 185 pounds per square inch gauge and the steam temperature was 500 degrees Fahrenheit. After the installation of the topping units, the eight low-pressure units remained as before.

Before 1943, the eight generators were connected to a 13-kv bus of four sections, and there were six 13-kv ties to the company's Hell Gate station, with a total capacity of 60

Essentially full text of paper **49-291,** "The Performance of a Topped Steam Power Plant on Sudden Load Reduction," recommended by the AIEE Committee on Power Generation and approved by the AIEE Technical Program Committee for presentation at the AIEE Fall General Meeting, Cincinnati, Ohio, October 17–21, 1949. Scheduled for publication in AIEE *Transactions*, volume 68, 1949.

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megawatts. There were two 45-kv ties with a total capacity of 42 megawatts connected to the system via the Laconia Avenue substation; these still exist but are now operated from an isolated bus section at Sherman Creek. There was another 13-kv, 8-megawatt tie to the system via the Columbus Avenue substation. The total tie capacity was therefore 110 megawatts, and the locally distributed peak load was 80 megawatts.

The first topping turbogenerator unit, rated 50 megawatts at 0.8 power factor, was installed in 1943. By that time the two end bus sections had been modernized by the installation of metalclad, phase-isolated busses with modern switchgear. The tie feeder situation remained virtually unchanged. By means of this installation the station capacity was increased from 171 megawatts to 221 megawatts.

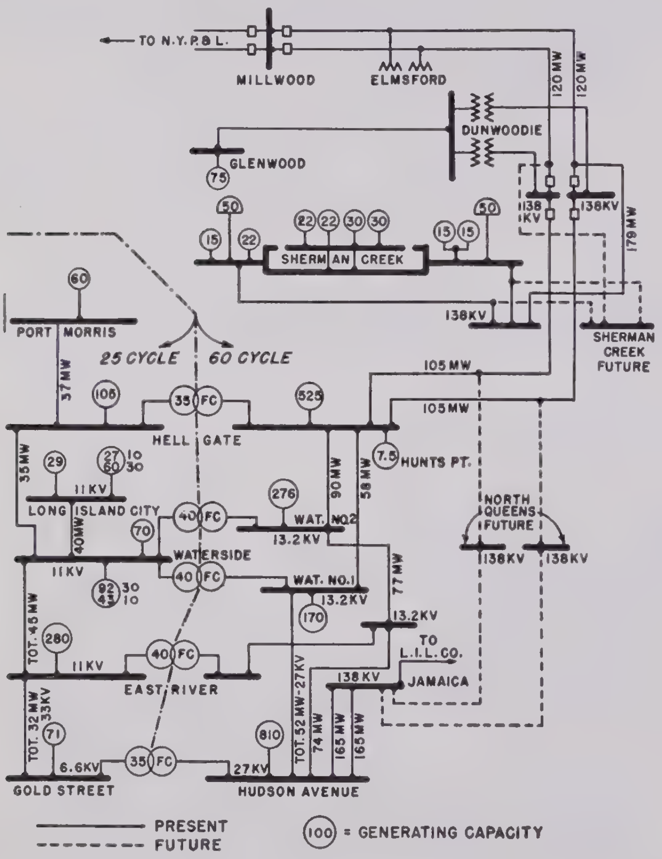

Figure 1. Diagram of the Consolidated Edison Company's metropolitan system

The steam generating equipment for the first topping turbogenerator consists of a Combustion Engineering Company pulverized-coal fired, wet bottom boiler with a capacity of 1,000,000 pounds per hour at 950 degrees Fahrenheit. The furnace is equipped with gas ignition torches operable from the control board. Automatic combustion control and boiler water level control are provided. The boiler feed pumps and fans are turbine driven.

In 1947 the second topping turbogenerator was installed and the 138-kv tie feeder, connected at the Dunwoodie substation to an existing tie from Hell Gate to the Niagara-Hudson system, was established. This turbogenerator was also rated at 50 megawatts, 0.8 power factor; its installation added another 50 megawatts to the existing station capacity of 221 megawatts, producing a new total of 271 megawatts.

The steam generation equipment for the second topper is a duplicate of that provided for the first, except that it is pulverized-coal-and-oil firing for load carrying, and uses steam atomizing burners for oil ignition. The lower coal burner is bifurcated to provide better air-coal mixing to minimize sulphiding. The oil ignition torches must be lit manually at the burners.

To provide space for the topping turbogenerators, 18 of the old boilers were removed, leaving 32 with a total capacity of 1,900,000 pounds per hour.

With the installation of the new 138-kv tie, which has a capacity of 179 megavolt-amperes, the six Hell Gate ties were discontinued because they could not be operated in parallel with the new 138-kv tie at high loads.

The present interconnection of the Sherman Creek station with the remainder of the company's system is shown on Figure 1. The planned future development is also shown. Figure 2 shows the present bus arrangement at the Sherman Creek station together with planned future expansion. Figure 3 shows the connections of the steam equipment.

The generating capacity, the station bus load, and tie feeder capacity at the Sherman Creek station is summarized in Table I. This tabulation shows that the Sherman Creek station may be exposed to a sudden load reduction of up to 179 megawatts on trip-out of the 138-kv tie feeder at times when the station local bus load may be at any value between 20 and 100 megawatts.

Table I. Bus and Feeder Capacity

Generating capacity	271 megawatts
Local bus load, including the Laconia Avenue and Columbus Avenue ties	190 megawatts peak 20 megawatts off-peak
Dunwoodie 138-kv tie capacity	179 megawatts

THE OPERATING PROBLEM

Under normal operating conditions, the load served from the Sherman Creek station is essentially of the metropolitan type; load changes are small in amount and of slow nature. For this reason it has never been found necessary to use automatic voltage regulation on any of the generators. Automatic load-frequency regulation is available for the purpose of maintaining the tie feeder load.

The Sherman Creek station is located on the northern end of the metropolitan system of the company, where there is available charging kilovolt-amperes from the capacitances of the 138-kv ties. Because of this and because of the small local load, the reactive kilovolt-ampere requirements are small and this station normally operates with a power factor which ranges between 0.90 and 0.95.

The operating problem which presents itself on sudden load reduction because of the trip-out of the 138-kv tie feeder may be resolved into three major phenomena which are interrelated. They are

1. The effect of the voltage and frequency rise upon the remaining consumer load.

2. The effect upon the low-pressure steam header pressure, to which are connected the major boiler auxiliaries, such as the turbine-driven induced and forced draft fan and boiler feed pumps.

3. The effect on the water level and the maintenance of ignition in the high-pressure boilers.

THE THEORETICAL INVESTIGATION

Because automatic voltage regulation is not available in this station, the magnitude and duration of overvoltage depends largely upon the time it will take the operators to restore conditions to normal. In the theoretical investigation it was assumed that the activities of the operators have no effect upon the maximum voltage which is reached in a few seconds.

The factors which affect the voltage rise are

1. The initial conditions, tie-line load, bus load, power factor, and generator capacities.

2. The effect of the change of load and power factor on the generator voltage at constant speed.

3. The effect of the change of load on the frequency or the turbine speed, which in turn is a function of the behavior of the turbine governors. This affects the voltage cumulatively because of the action of pilot and main exciters with increasing speed.

Although the calculation of the first two factors is simple and straightforward, difficulty was experienced with the third, not because of the difficulties in the basic approach, but because of the difficulty in obtaining the necessary governor constants. The result of these calculations is given in Table II.

In the calculation of factor 2, the effect of load and power factor change on the generator voltage, there are two different conditions which can be discerned by inspection of Figures 1 and 2. These two conditions are the tripping of the 13-kv circuit breakers on the low-tension side of the tie feeder transformers at Sherman Creek station, and tripping of the Millwood substation and the Dunwoodie substation tie feeder circuit breakers without simultaneous tripping of the Sherman Creek end. In this case the tie feeder with its capacitance charging current of 30 megavolt-amperes at rated voltage would remain connected to the Sherman Creek station bus. As far as voltage rise is concerned, the latter situation would represent the most severe case. However, since this case cannot arise under fault conditions without the simultaneous failure of the Sherman Creek station tie feeder circuit breaker operating mechanisms or their control circuits the probability of it happening is negligible. Under normal conditions, the tie feeder capacitance could be left on the Sherman Creek bus only by the erroneous operation of three circuit breakers at different locations; this is an operation which is equally unlikely. For these reasons such an operation was not considered in the investigations.

The effect of the voltage rise upon the remaining consumer load was calculated by assuming the load to have constant impedance. From checks of data available from tests previously made on parts of the company's system and from comparison with data in the technical literature[1–3] it was concluded that the error thus made was small in the expected voltage range. No consideration was given to the possible reduction of the consumer load because of lamp burnout, since it was known from previous experience that a voltage rise up to 25 per cent is acceptable from this standpoint if the duration of such a rise does not exceed one minute.

In the study of the second part of the operating problem, the effect of sudden load reduction upon the behavior of the low-pressure steam header pressure, there are also a number of factors to be considered. These are

1. The performance of the high-pressure and low-pressure turbine governors.

2. The amount of low-pressure boiler capacity and the amount of steam storage capacity, represented by banked boilers and by the volume of the steam piping.

3. The time limit imposed on the operators by the restrictions in motoring time on the topping turbines.

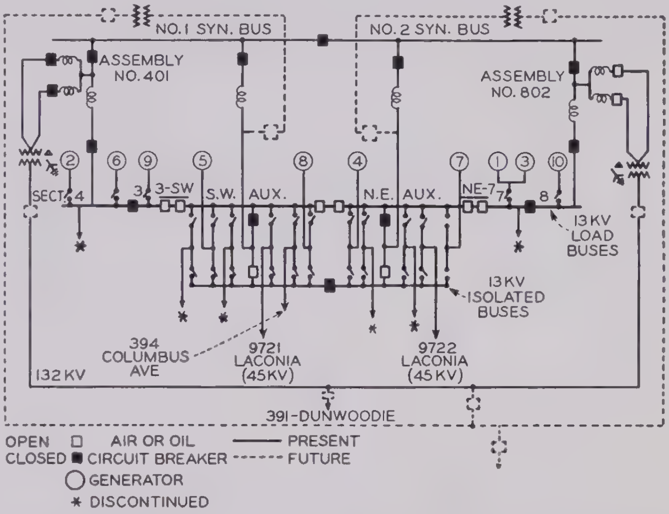

Figure 2. Diagram of the electrical connections of Sherman Creek station

The data available for the study of the first factor were meager. Although the regulation at steady state was known for the different governors, there was no information available on the incremental regulation nor on the time constants involved in the problem. Because of this lack of definite information, the following assumptions were made.

1. The steady-state regulation curves are combinations of straight lines within the range involved, and these curves give the ultimate speed.

2. Governors, having reasonably equal regulation and time constants, may be lumped together and represented by an equivalent governor.

3. For the low-pressure turbine governors a maximum valve gear travel time could be assigned, and the valve gear travel speed would be proportional to the instantaneous difference between the actual speed at the moment and the speed called for by the regulation curves for the respective units.

4. A linear relation exists between the output of the generator and the position of the valve gear.

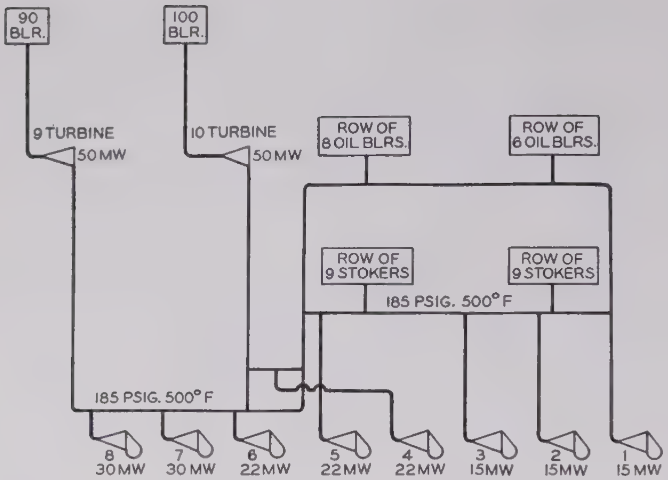

Figure 3. **Schematic diagram of the steam piping and connections**

Boiler 90 operates at 1,000,000 pounds of steam per hour at 950 degrees Fahrenheit

For the determination of the behavior of the low-pressure steam header pressure the system can be represented by an electric circuit as shown in Figure 4. From this representation it can be seen that the two regulating devices, representing the turbine governors, are not independent as far as the regulation of the steam flow is concerned. They do affect the low-pressure header pressure independently, however.

This study produced the set of curves shown in Figure 5 and the data given in Table II.

From this study the following conclusions were reached.

1. With the usual power factor of the load on the tie feeder equal to 0.95 or higher the voltage rise would not exceed 25 per cent.
2. For the maximum load reduction by tie feeder trip-out the frequency rise would not exceed 6 per cent.
3. The faster governors of the topping turbogenerators are primarily effective in limiting the frequency rise.
4. The behavior of the low-pressure steam header pressure is determined by initial loading and by the incremental regulations of the two groups of governors. The governors also determine the load division.
5. Low-pressure steam storage helps in reducing the rate at which the pressure in the low-pressure header changes.
6. The ratio of available low-pressure steam generation to the remaining bus load determines the extent to which the topping units will tend to motor.
7. Judicious removal of excess generating capacity is the quickest way for the restoration of normal conditions.

From these theoretical investigations proper operation of the boiler was formulated. On trip-out at high loads if the operator promptly removes one of the high-pressure generators together with the proper number of low-pressure generators, the low-pressure header pressure can be kept within reasonable limits so that the boiler feed pumps will be available to prevent dangerously low water levels in the high-pressure boilers while these boilers are blowing off steam through their safety valves. Since the number 90 boiler has gas ignition, it should be removed rather than the number 100 boiler which must be lit manually.

The prompt removal of excess generating capacity also reduces the tendency toward motoring of the remaining high-pressure unit, thereby avoiding the need to shut it down when the permissible motoring time of 30 seconds on one, 45 seconds on the other, has expired. By avoiding shutdown the boiler operation problem was considered well within the capability of the operating personnel and no damage to station equipment was anticipated.

TESTS AND UNSTAGED TRIP-OUTS

Because the investigation showed that the Sherman Creek station would be able to ride through the most severe sudden load reduction without damage to company or consumer equipment provided that the operators acted quickly and correctly, it was decided to stage tests. Such tests would provide the means for checking the method of calculation and the correctness of the assumptions as well as give valuable training to the operators. Arrangements were made for two tests, the first to involve a load drop of 50 megawatts, and the second, 100 megawatts, that is, 52 per cent and 60.5 per cent of the initial station load respectively.

The first test was made in January 1948, and the second was made in March 1948. However, on February 4, 1948, an accidental trip-out of the tie feeder occurred giving a load drop of 170 megawatts. The results of the tests and those of the accidental trip-out are tabulated in Table III. In the accidental trip-out, a complete shutdown of the local load was avoided only because of the availability of low-pressure steam generation at the time. Both topping turbogenerators had to be removed from the bus because of motoring. The number 9 unit motored because of a faulty throttle valve which closed and could not be reopened with full steam pressure, and the number 10 unit motored because an incorrect adjustment of the overspeed device caused its valves to close. These conditions have been repaired.

By comparing Tables II and III and from inspection of Figures 5 and 6, it can be seen that the theoretical method

Table II. **Calculated Performance**

	Megawatts Nominal Load Drop		
	50	100	170
Assumed conditions—adjustments*	None	None	None
Total load			
Megawatts	76	122	220
Megavolt-amperes reactive	43	60	107
Tie line load			
Megawatts	51	100	170
Megavolt-amperes reactive	24	43	70
Bus load			
Megawatts	25	22	50
Megavolt-amperes reactive	19	17	37
Generating capacity on bus—megavolt-amperes			
Initial	133	220	254
Final	133	220	254
Bus voltage—kilovolts			
Initial	13.5	13.6	13.6
Maximum	15.6	15.9	17.1
Final**	15.4	15.9	17.1
Frequency—cycles per second			
Initial	60	60	60
Maximum	62.7	63.3	63.3
Final**	61.2	61.5	61.9
Low pressure header pressure—pounds per square inch gauge			
Initial	200	202	200
Final**	216	196	

* No manual adjustments were assumed to be made for a 15-second period following the trip-out.

** At 15 seconds.

employed in these investigations closely predicted the actual performance.

During both staged tests for which the boiler-operating personnel were fully prepared and armed with detailed instructions, all equipment functioned correctly, and the operators controlled all essential boiler operating functions without difficulties. Prolonged motoring of the high-pressure turbines was avoided, and there was no trouble with the maintenance of the boiler drum water levels.

However, the unstaged trip-out of February 4, 1948, created additional problems because of the closing of the turbine valves on both topping units.

With the loss of both topping units, the electrical operator did not trip low-pressure units, but tried to maintain the remaining station load with them. In doing so, he caused the low-pressure header pressure to drop to 145 pounds per square inch gauge, which, in turn, caused water carry-over and, because of the sudden chilling, leakage in all flanged joints in the low-pressure piping system.

Delayed by having to light manually the oil ignition on the boiler, it was ten minutes before the number 10 unit could be synchronized, whereas, the number 10 unit could have been back on load in one or two minutes if remote-controlled gas ignition had been available.

Anticipating the momentary opening of the number 9 unit throttle, the number 90 boiler operator cut in the gas ignition and held a mill in service for one minute. During this period, the steam pressure rose to 1950 pounds per square inch and was still climbing when the ignition and mill were cut off. At this high pressure much steam escaped through the safety valve expansion slip joints and clouded the entire area, rendering the boiler water columns invisible. However, the drop in drum water level was held to 13 inches by manual operation of the boiler feed pumps. (The safety valve joints have been modified to prevent a recurrence of the condition.) As the number 9 unit throttle had closed due to unbalanced pressures, the boiler pressure had to be reduced materially before the valve could be reopened. As a result, it was 17 minutes before the number 9 unit was returned to service.

Table III. Actual Performance

	Megawatts Nominal Load Drop 50	100	170
Nature of trip-out	Staged test. No adjustments for 15 seconds	Staged test. Immediate manual adjustments	Accidental relay operation
Total load			
Megawatts	76	122	220
Megavolt-amperes reactive	43	60	107
Tie line load			
Megawatts	51	100	170
Megavolt-amperes reactive	24	43	70
Bus load			
Megawatts	25	22	50
Megavolt-amperes reactive	19	17	37
Generating capacity—megavolt-amperes			
Initial	133	220	254
Final	133	98	129
Bus voltage—kilovolts			
Initial	13.5	13.6	13.6
Maximum	15.5	15.6	16.9**
Final*	15.2	15.0	
Frequency—cycles per second			
Initial	60.0	60.0	60
Maximum	62.7	62.8	
Final*	61.2	61.6	
Low-pressure header pressure—pounds per square inch gauge			
Initial	200	202	200
Final*	212	198	

* Final means at end of 15-second period.

** Maximum up to point where power transformer fuse blew.

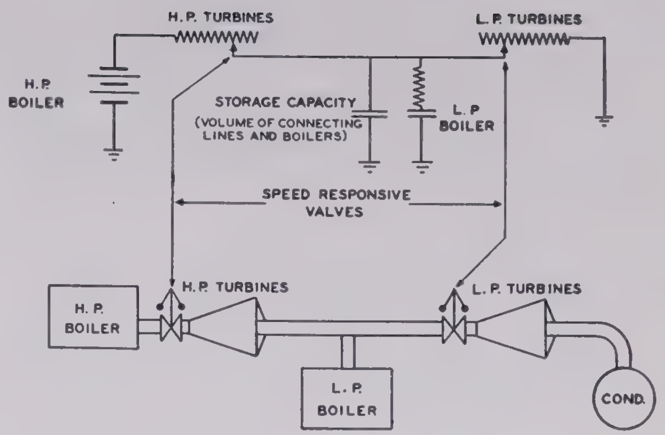

Figure 4. Electrical analogue of steam flow

The exact sequence of events and operations was made more difficult to reconstruct as some of the instruments did not record rapidly enough. These were principally the multipoint recording type. Some of the instruments were not set exactly on the correct time. Some of them stopped at the crucial moment because of blown fuses caused by overvoltage at the time of trip-out. The operators were busy and many of the indicating instruments went unread and unlogged.

AUTOMATIC CONTROL DEVICES

During one stage of the investigation, consideration was given to the installation of automatic devices for assisting the operators in controlling the voltage rise and for controlling the low-pressure header pressure.

For the control of overvoltages, installation of standard voltage regulating equipment on all generators was considered. This involved the installation of new exciter field rheostats on all but the two topping units, because the existing rheostats were not suitable for use with automatic voltage regulating equipment. The cost of such an installation would not have been justified on the basis of alleviating an infrequently expected emergency condition.

As a cheaper means of reducing voltage rise, a scheme using voltage relays set above the normal operating voltage to lower the exciter field rheostats to a preset position was investigated. This would have eliminated the need to purchase new field rheostats but was not practical because it might create instability by depriving a loaded generator of a sufficiently high field excitation to assure maintenance of synchronism.

To maintain low-pressure header pressure and to prevent prolonged motoring of the remaining high-pressure turbine, an automatic scheme for tripping excess generator capacity was considered. With this scheme the operator would preselect the units he would want removed from the bus quickly in case of a trip-out of the tie feeder. A voltage relay set to a certain over-voltage would then trip these preselected units. Because of the operator's aversion to a

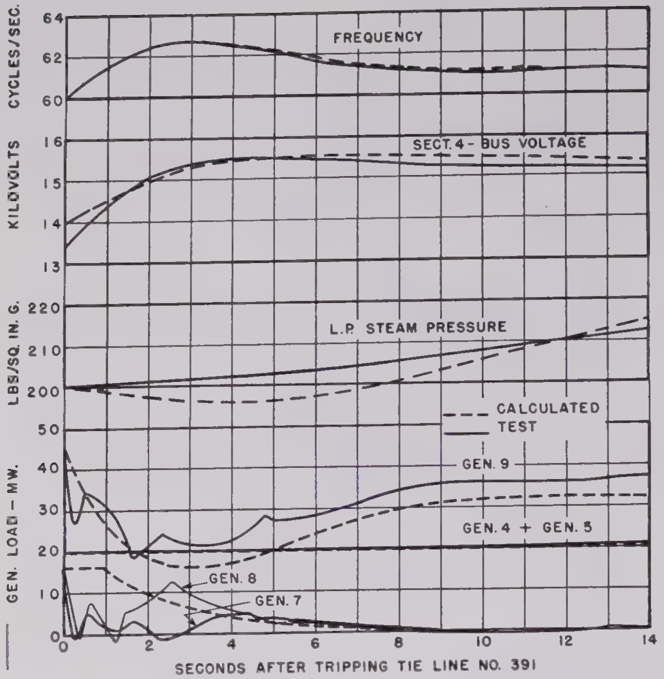

Figure 5. Comparison of theoretical computations with test results

50-megawatt load drop

scheme which would automatically remove the generating capacity of several units in case of failure of a single device, such as a relay, this scheme was abandoned.

No additional automatic devices were ever considered for application to the boilers; in fact, the operators invariably resort to manual control of the boiler in all emergencies.

In view of the tests and on the basis of five actual, unstaged trip-outs a final decision was made not to provide automatic devices specifically for the trip-out problem.

OPERATING GUIDES

From the wider understanding of the problem provided by the theoretical investigation and from the experience which was gained by the operators through tests and unstaged trip-outs, the following operating guides were formulated.

I. For the electrical operator:

A. He must be prepared for a sudden load reduction equal to the load carried by the 138-kv tie feeder under all station load conditions and at all times. Depending on the load conditions, he must know whether or not generating units have to be dropped, and if so, he must have decided which ones.

B. The electrical operator's plan for action must be agreed on by the turbine and the boiler operators, and all three must keep informed of changing conditions and plans.

C. Depending on load conditions, the electrical operator is to proceed as follows on sudden loss of load:

1. Trip off the preselected units promptly.
2. Reduce frequency further, if required, by reducing the load on the heaviest loaded remaining units.
3. Reduce voltage, if required, by reducing the excitation, beginning with the lightest loaded units, always taking care to maintain a lagging power factor.
4. In reducing load, be guided by the low-pressure header pressure and by motoring limitations on the higher pressure generators.

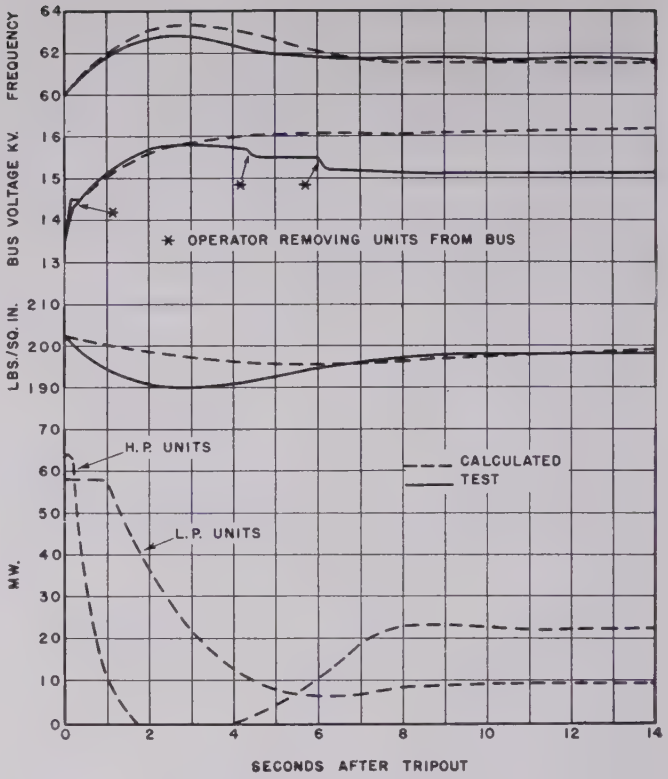

Figure 6. Comparison of theoretical computations with test results

100-megawatt load drop

II. For the turbine operator:

Secure all turbines tripped by the electrical operator and prepare them for resynchronizing when required.

III. For the boiler operator:

A. Switch to manual combustion and feed water control.

B. If a high-pressure turbine has been tripped, secure the associated boiler in a normal manner.

C. On the remaining high-pressure boiler, keep a heavy coal feed on the bottom burners to prevent loss of ignition. Cut in the ignition torches immediately. If the drum water level drops below the danger point, cut off all coal feed.

D. Cut in low-pressure boilers and force these to steaming in accordance with the prearranged program.

CONCLUSION

Theoretical investigation, staged tests, and actual case experiences, show that a topping turbine steam generating station can successfully operate through sudden load reductions up to 90 per cent of initial load without damage to plant or remaining consumer load equipment. The complete understanding of the problem by the operators, together with preparedness and co-operation on their part, is a prerequisite for the successful handling of such an emergency.

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A Bushing Design for High Altitudes

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THE STEADILY INCREASING USE of electrical components at high voltages and altitudes has presented a problem in the design of bushings to meet the requirements of being corona- or radio-interference-free in the range of 10,000 volts and altitudes of 50,000 feet.

A transformer design was required to supply 8.6 kv with mid-point grounded. The porcelain would have to stand 9.6 kv to ground for one minute and be corona- or radio-interference-free at 25 per cent over rated voltage.

In the solution of this problem, the law of similitude was applied directly. This law states that in cases where the parts remain in the same proportion, and the dielectric field has the same shape, the breakdown voltage will remain constant provided the sizes of the parts vary inversely as the gas pressure.

Several designs were considered and that of Figure 1 was selected. It was chosen because there is no concentration of stress at the edge of the metal parts or the flange in air and there is no concentration of stress in the air at the terminal parts. This means the design might be corona-free nearly up to the breakdown voltage, hence could be of small dimensions relative to its voltage strength.

To check this, a commercially available porcelain of the same dimensions was tested. The bushing was mounted using a metal washer, stud, and nut as the termination. Corona formed on the terminal washer at 12 kv and flashover occurred at 22 kv. The bushing was modified to determine the strength at the flange and then further modified to the final design. With a short length of number 10 wire extending from the terminal, no corona appeared on the terminal before breakdown which occurred at 7.7 kv at 3.15 inches of mercury, but corona formed at the terminal at 24.5 kv at normal pressure.

To compare the results with those expected, by using Figure 2 we may determine an equivalent outer cylinder diameter. In the case of the hemispherical terminal we use a one-half-inch inner cylinder diameter which corresponds to the one-half-inch terminal. The equivalent outer cylinder for a 2-inch string distance between flange and terminal would be equal to 4.5 inches. This yields a constant ratio of 4.5/0.5 or 9. The corona point corresponding to these conditions would be approximately 36 kv. Applying the law of similitude, at 3.4 inches of mercury pressure the bushing dimensions would be reduced by the factor 30/3.4. The corona voltage of the imaginary small bushing at atmospheric pressure would be the same as that of the full-sized bushing at 3.4 inches of mercury. It is seen that the 7.7 kv noted is within the range of expected value.

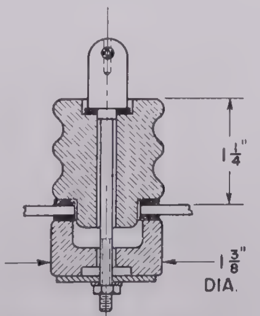

Figure 1. Final bushing design

Terminal is one-half inch in diameter and seven-eighths inch long. String distance from flange to terminal is about two inches. At room temperature and 3.4 inches of mercury pressure (corresponding to 50,000 feet altitude), corona and breakdown occurred simultaneously at about 6.3 kv. Bushing is satisfactory, since it only had to meet a 5.4 kv test value

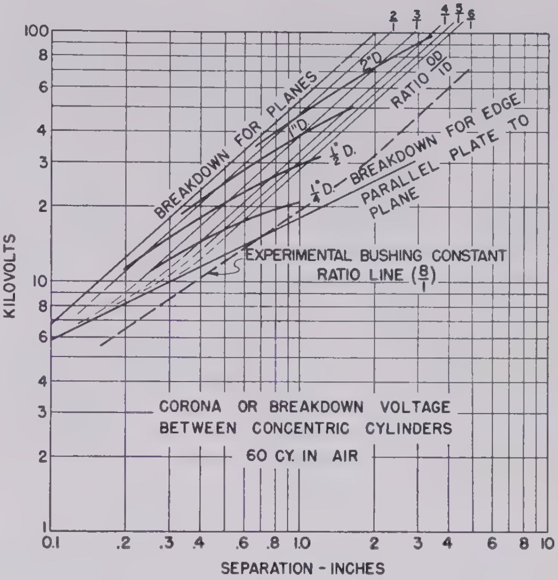

Figure 2. 60-cycle corona voltage for concentric cylinders and final bushing constant ratio line

The final bushing design was tested at atmospheric pressure where corona started at the flange at 27 kv and breakdown occurred at 28.5 kv. At 3.4 inches of mercury corona and breakdown occurred simultaneously, at about 6.3 kv. By using Figure 2, a means of a first approximation to a bushing design has been presented. The fields associated with a bushing only approach those of concentric cylinders, and, as is evident from the final bushing design, the values to be expected for a bushing will be somewhat below those for corresponding cylinders. The conditions at the flange are seen to be severe and elimination of stress at this point especially at atmospheric pressure, is necessary. The final bushing, as designed, is about the proper proportion since corona and breakdown occurred at approximately the same value. Once having established the proper proportions, an equivalent constant ratio (OD/ID) line may be drawn, whence it becomes a simple matter to calculate new bushing dimensions and to estimate the performance of the design.

Digest of paper **49-194,** "A Small High-Voltage Bushing Design for High Altitudes," recommended by the AIEE Transformer Committee and approved by the AIEE Technical Program Committee for presentation at the AIEE Summer General Meeting, Swampscott, Mass., June 20–24, 1949. Scheduled for publication in AIEE *Transactions,* volume 68, 1949.

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A Wide-Range Adjustable-Speed Drive

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WHEN a d-c series motor is supplied with a voltage which is proportional to its current, its speed is essentially constant for various values of output power. The operating speed of the motor is directly proportional to the rate of change of this voltage with respect to the current.

The power to drive the d-c series motor is obtained from two d-c series machines driven at constant speed and connected in series. One of these machines performs as a generator, the other may act either as a motor or a generator depending upon the speed desired from the d-c motor. An infinite number of speed settings is obtainable by adjustments of the diverters on the series fields. Series resistances have been eliminated in the power circuits, thereby providing high efficiencies. Regenerative braking can be incorporated in the supply circuit, thereby permitting rapid deceleration. The entire circuit can be assembled from standard commercial equipment. Constancy of speed over the entire range of torques available is exceptionally good. The available horsepower for different speed settings is proportional to the operating speed; that is, the system is a constant-torque drive. Experimental tests indicate that a 20-to-1 range of speeds is easily attainable. Specially designed and co-ordinated units may extend this range of speed. The system is exceptionally stable throughout the operating range.

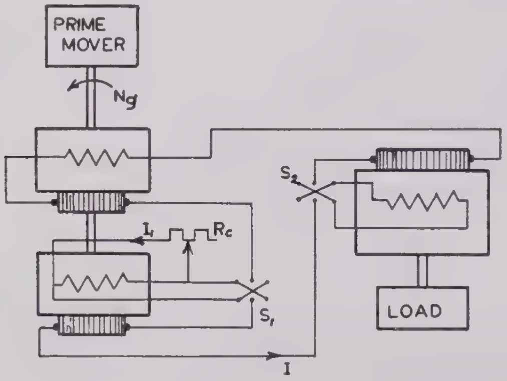

Figure 1. Circuit for wide-range adjustable-speed drive

1—Series generator *2—Series motor or generator* *3—Series motor*

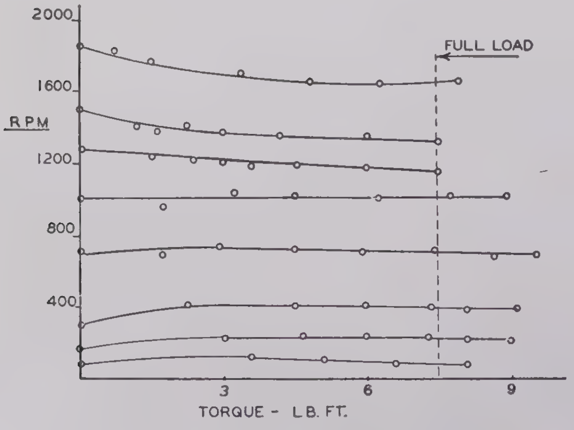

Figure 2. Characteristics of motor 3 in the circuit of Figure 1

The speed characteristics are attainable by analyzing the circuit in Figure 1. The constants used are shown in Table I.

Table I. Circuit Constants

	Machine I (Generator)	Machine II (Motor or Generator)	Machine III (Motor)
Armature resistance	Ra_1	Ra_2	Ra_3
Field resistance	Rf_1	Rf_2	Rf_3
Generated voltage	Eg_1	Eg_2	Eg_3
Total flux	ϕ_1	ϕ_2	ϕ_3
Speed	Ng	Ng	N_3
Armature constants	K_1, K_1'	K_2, K_2'	K_3, K_3'
Armature current	I	I	I
Field current	I	$I-I'$	I

The sum of the voltages around the circuit is

$$Eg_1 \pm Eg_2 - I\left(Ra_1 + Ra_2 + Rf_1 + \frac{Rf_2 Rc}{Rf_2 + Rc}\right) = Eg_3 + I(Ra_3 + Rf_3) \tag{1}$$

Let $(Ra_1 + Ra_2 + Rf_1 + Ra_3 + Rf_3) = R$

$$\therefore\ Eg_1 \pm Eg_2 - I\left(R + \frac{Rf_2 Rc}{Rf_2 + Rc}\right) = Eg_3 \tag{2}$$

$$Eg_1 = K_1'\phi_1 Ng = K_1 I Ng \tag{3}$$

$$Eg_2 = K_2'\phi_2 Ng = K_2(I - I')Ng \tag{4}$$

$$I - I' = \frac{I Rc}{Rf_2 + Rc} \tag{5}$$

$$Eg_2 = K_2 \frac{Rc}{Rf_2 + Rc} I Ng \tag{6}$$

$$Eg_3 = K_3'\phi_3 N_3 = K_3 I N_3 \tag{7}$$

Substitute equations 3, 6, and 7 in equation 2.

$$K_1 I Ng \pm K_2 \frac{Rc}{Rf_2 + Rc} I Ng - I\left(R + \frac{Rf_2 Rc}{Rf_2 + Rc}\right) = K_3 I N_3 \tag{8}$$

$$N_3 = \frac{Ng\left(K_1 \pm K_2 \dfrac{Rc}{Rf_2 + Rc}\right) - R - \dfrac{Rf_2 Rc}{Rf_2 + Rc}}{K_3} = K - \frac{Rc}{Rf_2 + Rc}\left(Rf_2 \pm \frac{K_2 Ng}{K_3}\right) \tag{9}$$

where $K = \dfrac{K_1}{K_3} Ng - \dfrac{R}{K_3}$

It is evident from equation 9 that for a given setting of the rheostat *Rc* the speed of the motor is constant and is independent of current and torque.

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Television Terminals for Coaxial Systems

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The L-1 coaxial television terminal equipment functions to change video frequencies upward so that they can be transmitted by the coaxial line and to restore the signal to its original form after transmission. This article describes the design and properties of terminals used in a system which transmits signals containing frequencies from a few cycles per second upwards to four megacycles per second.

THE broad features of the operation of the *L-1* coaxial system for the transmission of television have been public for more than a year,[1] but thus far the factors influencing the design of the coaxial television terminals and a detailed discussion of the equipment now in service in the Bell Systems' television network have not been published. The television terminals here described were placed into network service in 1947, but in basic form are similar to experimental models developed prior to the war and used in early television transmission studies over the coaxial cable.[2,3]

FREQUENCY ALLOCATIONS

The nominal transmission band of the *L-1* coaxial line extends from 64 kc to 3,100 kc. In contrast to this available band, the television video signal nominally occupies the frequency region extending from a few cycles per second upwards to four megacycles. It is the function of the television terminals properly to translate this video band of frequencies upwards into the transmission region of the coaxial line and after transmission over the system to restore the television signal to its original video form for use by the broadcaster.

In addition to the necessity for frequency translation of the video signal it is apparent that the over-all available band width for television transmission is somewhat less than three megacycles. Numerous experiments have been conducted with a view toward evaluating the subjective loss of sharpness of a television image with restricted transmission bands.[4] It is sufficient to say here that a definite visible effect requires a change in band width somewhat in excess of one megacycle in a 4-megacycle system, which is the increment we are here concerned with. The practical operation of the *L-1* coaxial system for television service during the past several years appears to confirm this conclusion.

The relative positions of the transmission band of the *L-1* coaxial system and the original video signal requires that frequency translation methods be employed. To preserve the greatest possible net band width it is apparent that double sideband transmission cannot be considered here. Single sideband transmission, however, involves great difficulties in a case such as this where the signal contains energy at frequencies of a few cycles per second.

The vestigial sideband transmission scheme here selected permits a relatively efficient utilization of the available band width and is practically realizable with presently available design techniques. The cost of frequency discrimination networks required to limit the extent of the vestigial sideband is inversely related to the vestigial band width. Certain transmission distortions increase inherently as the vestigial sideband width is reduced. These two factors, which will be discussed in more detail later, must be balanced against the desirability of utilizing the available band width to the fullest extent to achieve optimum transmission performance consistent with economic considerations. A vestigial-to-main sideband width ratio of approximately four per cent is here selected as representing a satisfactory condition for the *L-1* coaxial system.

The delay distortion of a long coaxial system tends to increase rapidly at frequencies approaching the lower cutoff. While this is unimportant for telephone application, for television use precise delay equalization over the entire band is required. A study of the *L-1* coaxial system indicates that in consideration of the extent of delay equalization required for television a lower practical limit of 200 kc is advisable. This and the preceding considerations result in a main sideband width of approximately 2,800 kc with the vestigial sideband occupying approximately 100 kc.

The repeaters for the *L-1* coaxial line involve feedback amplifiers whose stability and modulation performance are allowed to decrease for frequencies exceeding two megacycles. Also, the noise tends to increase above two megacycles because of the higher coaxial cable loss. Since in general television transmission requirements are more lenient at the higher video frequencies, it is logical that the carrier be located at the lower end of the frequency band with the main sideband extending upward to 3,100 kc. These considerations then place the optimum location of the television carrier frequency in the region of 300 kc

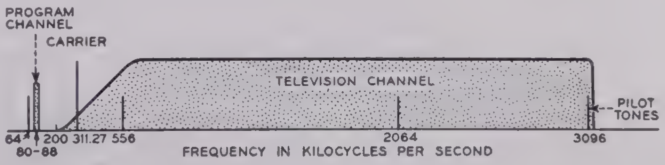

Figure 1. Television allocation for L-1 coaxial system

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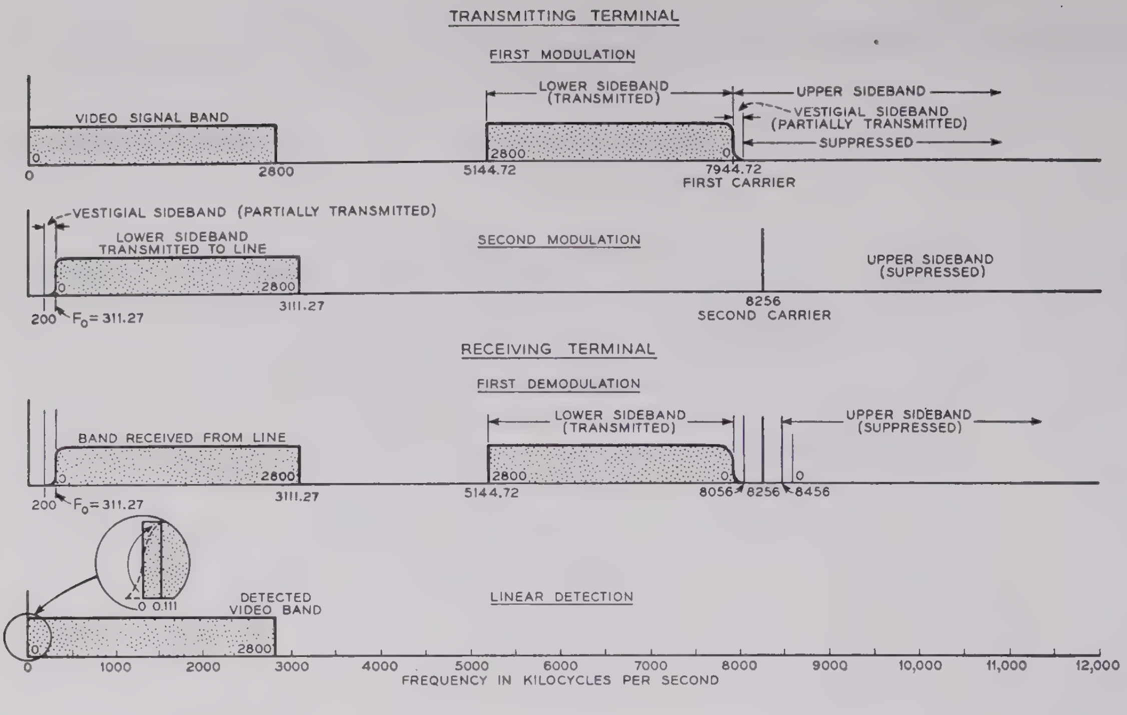


Figure 2. Modulation diagram for television carrier terminals

with the vestigial sideband extending downward to 200 kc and the main sideband upwards to 3,100 kc. The choice of exact location of the television signal in the available *L-1* coaxial band is made to take greatest advantage of certain characteristics of the television signal, the transmission properties of the coaxial line, and to permit simplification of operating and maintenance practices.

As described previously,[5] the television signal produced by scanning is composed of concentrations of energy located in frequency regions related to the line and field scanning frequencies and harmonics thereof. The alternate regions of low energy content may be considered as related to specific forms of complex detail rarely present in television scenes. In a converse fashion, the introduction of extraneous energy into these idle regions has been found to produce complex visual effects of which, in general, the viewer is very tolerant. In the television terminal designed for the *L-1* coaxial system this phenomenon is utilized where possible by locating the exact position of the transmitted television band so that existing unavoidable interferences fall within these regions of comparative insensitivity. For example, three of the pilot frequencies employed for gain equalization purposes are located at 556, 2,064, and 3,096 kc.[6] The effective interference produced by control tones with the transmitted televison carrier signal is reduced in this manner.

Another characteristic of the energy-frequency distribution of the television signal which is of importance here is the relatively high concentration of energy at the lower video frequencies and the usual diminution at the higher frequencies. It is possible to encounter variations in this characteristic when unusual specific scenes or test patterns are considered, but in the large majority of cases a considerable reduction of energy with frequency is the rule. By means of predistorting methods this energy-frequency characteristic is altered for transmission over the coaxial line resulting in improved transmission performance.

Another factor which influences the exact position of the transmitted television signal on the coaxial line is the practical problem of maintenance of these precise carrier frequencies over a nation-wide network. In the terminal design which will be described later, the highly stable coaxial line pilot frequencies which are always available are used as frequency reference standards in maintenance of this equipment.

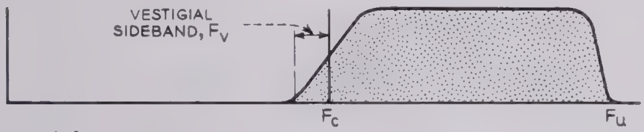
The exact location of the modulated television carrier signal as transmitted over the *L-1* coaxial system is shown in Figure 1. The television carrier is located at 311.27 kc. Provision is also made for transmission of the accompanying sound program by single sideband carrier means in the region of 80–88 kc. The equipment and methods employed here have been described recently.[7]

THE TERMINAL MODULATION PROCESS

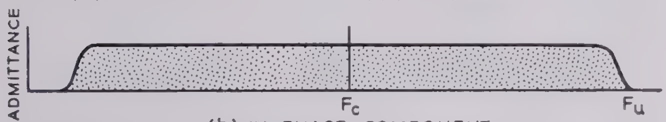
To achieve the translation of a band of frequencies by an amount small as compared to the band width, multiple modulation steps must be employed. Figure 2 illustrates the features of the double modulation process employed here. The original video signal extending from a few cycles per second upwards to almost three megacycles modulates a carrier frequency of 7.944 megacycles. The resultant lower sideband together with a vestige of the upper sideband as selected by the following band filter then modulates a carrier wave located at a frequency of 8.256 megacycles. The lower sideband of this second modulation step is selected by a following low-pass filter and now lies between 200 kc and 3,100 kc with the original zero video frequency now located at 311.27 kc. This frequency position is the one desired for transmission over the coaxial line. It should be noted that the vestigial shaping process is partially completed in the transmitting terminal, the remainder of this process being provided in the receiving terminal.

After transmission over the *L-1* coaxial line, a similar double demodulation process is employed to restore the signal to its original video form. The incoming carrier signal at the receiving terminal is first modulated with a carrier frequency of 8.256 kc. Following this, a band filter similar to that in the transmitting terminal selects the lower sideband and introduces the remainder of the vestigial sideband shaping. The resulting television carrier signal now falls in the region of from five to eight megacycles, and at this point envelope detection is employed to recover the video signal for transmission to the broadcaster.

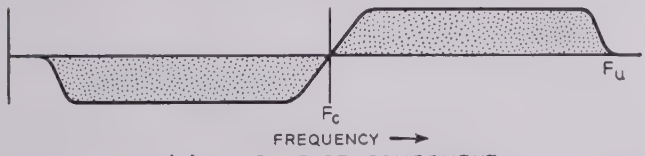
The choice of final demodulation by envelope detection rather than through the use of a local carrier demodulator results in a considerable simplification of the terminal equipment. For satisfactory operation of product demodulation in a television system such as this, it has been found it would be necessary to maintain the relative phase between the incoming carrier of the television signal and the local demodulating carrier to within one degree for satisfactory transmission performance. The realization of such phase precision throughout a nation-wide network would require extremely costly and complex terminal equipment. The satisfactory operation of a carrier television system which employs envelope detection, however, necessitates certain restrictions as to the form of the modulated signal envelope. However, in this system it was considered advantageous to accept these restrictions and employ envelope detection.



(a) VESTIGIAL SIDEBAND TRANSFER ADMITTANCE



(b) IN-PHASE COMPONENT



(C) QUADRATURE COMPONENT

Figure 3. Transfer admittance of a vestigial sideband carrier system

TELEVISION CARRIER TRANSMISSION

It is convenient in a discussion of vestigial sideband methods of carrier transmission to consider the resultant transmission effects as made up of contributions from two components, an in-phase or real component and a quadrature or distortion component. This method of analysis was originally described by Nyquist.[8] The process is illustrated in Figure 3. Here the transfer admittance shown in *a* represents the idealized conditions for vestigial sideband transmission. The main sideband is shown extending from the carrier frequency location F_c, upwards to F_u, the cut-off of the system. A vestige of the lower sideband extends from F_e downward as shown. In the region $F_c \pm F_v$ the admittance characteristic is so chosen that the sum of the admittances offered to any upper sideband frequency and the corresponding lower sideband frequency is a constant. In this idealized view a linear phase with frequency characteristic over the entire frequency band, a constant envelope delay, is assumed.

The vestigial sideband system admittance function shown in *a* may be considered to be equivalent to the sum of two other admittance forms illustrated in *b* and *c*. Both of the latter functions are of a double sideband form and may be treated as such functions. The admittance component shown in *b* represents a double sideband characteristic where the carrier is in phase with the original signal, and is capable of faithful reproduction of the original signal except for an amplitude constant. The second component shown in *c* represents a double sideband characteristic where the carrier is in quadrature with that of *b* and where each signal component has also undergone a 90-degree phase shift from that of Figure 3*b*. This component is referred to as the quadrature component and represents a distortion term. The complete vestigial characteristic is formed by the vector addition of the in-phase and quadrature components. Figure 4 illustrates the form of the in-phase and quadrature component of an idealized rectangular video wave form as obtained with the admittance functions of Figure 3. The form of the quadrature component is a function of the band width of the vestigial sideband, and its peak amplitude is inversely related to this band width. The contribution of this distortion term to the resultant output of a vestigial transmission system can be made as small as desired by providing an excess of in-phase carrier, supplied by local generators or contained in the transmitted carrier signal.

As discussed previously, the *L-1* television terminals employ envelope detection and here it is required to transmit an excess of in-phase carrier, to restrict the degree of modulation to maintain the quadrature distortion term to desired limits. Figure 5 illustrates the appearance of a television carrier signal of a rectangular video pulse within the *L-1* terminals just before final detection. The quadrature effects are visible here in the envelope.

The signal-to-noise performance of a carrier transmission system is directly proportional to the modulated amplitude of the transmitted signal. Given an upper peak amplitude limit which may be transmitted satisfactorily over such a system, it follows that an increase in the excess carrier ratio must be accompanied by a reduction in the signal modulation with a resultant poorer signal-to-noise

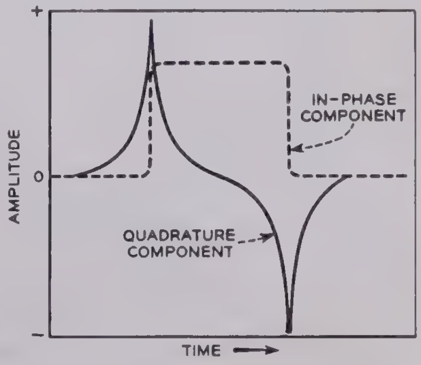


Figure 4. In-phase and quadrature components of a rectangular pulse

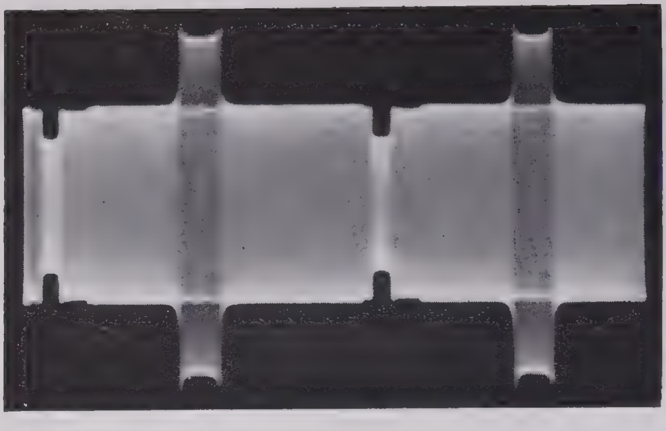


Figure 5. Modulated television carrier signal prior to detection

performance. The excess carrier condition shown in Figure 5 is presently employed in the *L-1* system and represents an economical balance between quadrature distortion and signal-to-noise performance.

It is of interest to consider the resultant effects of unwanted modulation distortion of the *L-1* carrier television signal introduced during transmission over the coaxial line amplifiers. In the case of transmission of a television signal in the original video form, all important energy components of the signal are harmonically related to the scanning frequencies. Under these conditions the introduction of modulation distortions, also of a harmonic nature, results only in a modification of the amplitude and phase of the original signal components, and the visual resultant is a distortion of the signal wave shape in a geometric sense. In the usual video case these effects are considered as a nonlinearity function applied to portions of the brightness range of the received picture. The eye is quite tolerant in this respect so that quite lenient video signal modulation requirements result.

In the case of carrier transmission of television signals, the regions of concentrated energy are not harmonically related by virtue of their displaced frequency position. Harmonic modulation products of this carrier signal are no longer simply related to the original signal components and extraneous frequency components are produced. As might be expected the modulation requirements under these conditions of carrier transmission are more severe than in the case of the video form of transmission.

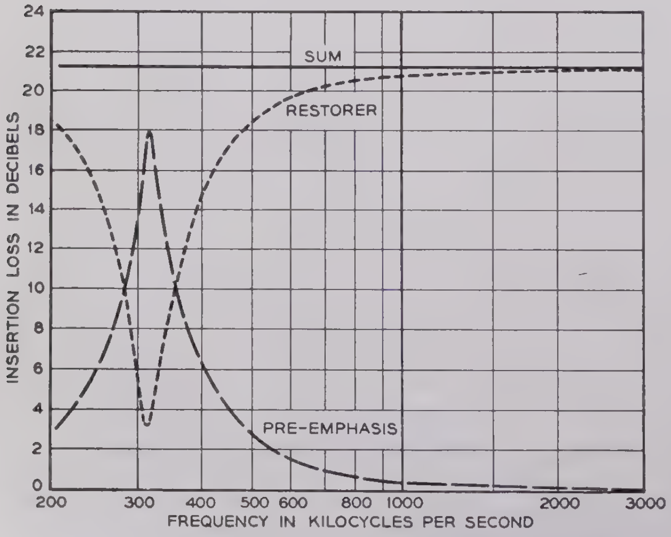


Figure 6. Pre-emphasis and restorer characteristics

In the present system the greatest amplitude modulation products are of a second and third harmonic nature and are formed by the carrier frequency and the high energy signal components in the immediate vicinity of the carrier frequency. The second harmonic of the carrier frequency will fall at 622 kc and the third harmonic at 933 kc. After final detection these extraneous distortion products will appear in the 311- and 622-kc regions respectively, where they produce extremely objectionable visual effects. There is, however, an advantage obtained in arrangement of the allocation as mentioned previously such that these products occur in the idle regions of the signal spectrum.

Pre-emphasis of the upper frequency components of the television signal is employed according to the frequency characteristic shown in Figure 6. By this means it is possible to introduce a complementary restoring characteristic as indicated in the receiving terminal which effectively reduces any extraneous interference including modulation effects above 400 or 500 kc on the coaxial line. Since the restorer characteristic is the exact complement of the pre-emphasis characteristic, the over-all transmission characteristic is unaffected. In this manner a theoretical reduction of 16 decibels of the second harmonic and 17 decibels of the third harmonic is effected. It should be noted here that in the process of pre-emphasis the peak factor of the carrier television signal is altered and therefore the extent of modulation improvement indicated is not completely realized in practice.

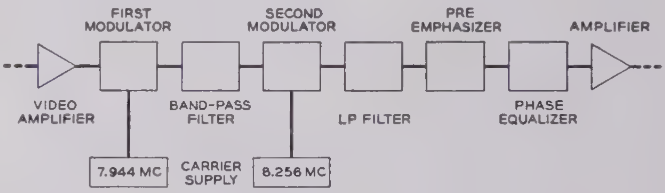


Figure 7. L-1 coaxial television transmitting terminal—block schematic

TRANSMITTING TERMINAL EQUIPMENT

A block schematic of the elements of the *L-1* coaxial television transmitting terminal is shown in Figure 7. This terminal provides for the translation of the video signal upward into the transmission band of the *L-1* coaxial line. The double modulation method has been shown previously in Figure 2.

The video signal to be transmitted over the *L-1* coaxial system is received from the network operating center over a balanced 110-ohm video transmission circuit. The first modulator unit consists of a video amplifier, d-c inserter modulator, and associated carrier supply.

The d-c inserter consists of a germanium crystal element

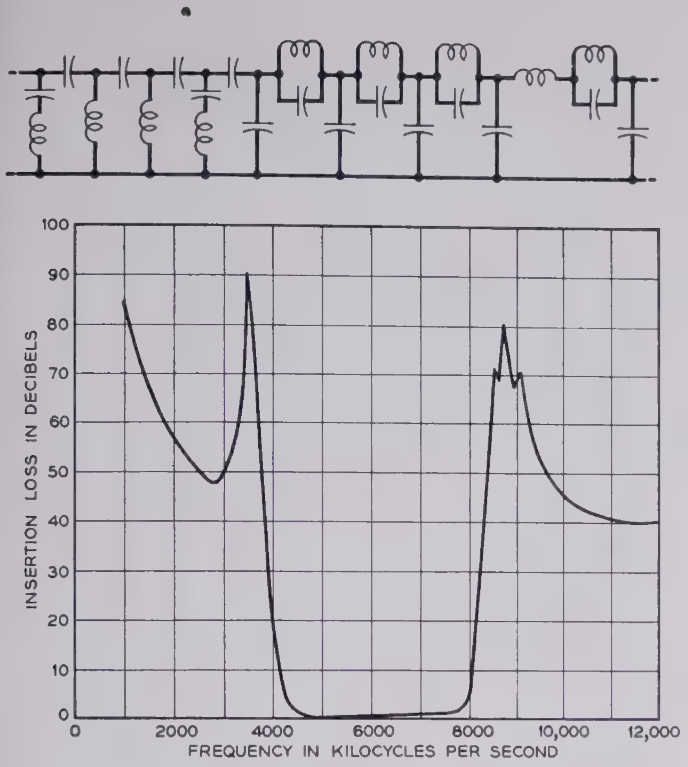


Figure 8. Band-pass filter—configuration and loss characteristics

connected so that in conjunction with the coupling capacitors, the extremes of the standard television synchronizing pulses are always maintained at zero potential with respect to the modulator grids regardless of the picture content of the video signal. In this manner the peaks of the synchronizing pulses correspond to a fixed amplitude of excess carrier which, as previously discussed, is desirable when envelope detection is employed.

The video signal which now contains the d-c component is impressed upon the grids of a balanced modulator while the carrier voltage is introduced in a conjugate manner into the cathode circuit. The excess carrier to be transmitted is provided by unbalancing the modulator by differentially varying the screen voltage of each modulator tube by the desired amount. To assure that this excess carrier component is in exact phase relation with that modulated by the input video signal, an additional phase or quadrature balance control is provided. This circuit arrangement allows any carrier leak which may be present in the modulator plate circuit, due to transmission through the tube elements or other parasitic reactances, to be independently balanced out. The carrier frequency of 7.944 megacycles is generated in a crystal-controlled oscillator and provides, through a buffer amplifier stage, approximately five volts of carrier to the modulator proper.

Figure 8 indicates the network configuration and the frequency-loss characteristic of the band filter which selects the lower and vestigial sideband of the first modulation step. This network is formed of low-pass and high-pass sections. This particular configuration here results in an economy of coils, desirable because of the practical difficulties of such elements with respect to parasitic capacities. Small compact assemblies also result with this design as well as certain advantages in control of cut-off characteristics in design and manufacture. At this point only partial shaping of the vestigial sideband is accomplished. Further networks in the transmitting and receiving terminals also contribute to this total shaping.

The second step of modulation follows the band filter selection of the signal in the 5- to 8-megacycle region. The second modulator is supplied with a carrier frequency of 8.256 megacycles. The balanced modulator and carrier supply oscillator is similar in circuit form to that described for the first modulation step. By the use of a balanced modulator certain second order unwanted modulation products are reduced to noninterfering levels.

Following the second modulation process, a low-pass filter assures that unwanted 5- to 8-megacycle signal energy and the upper sideband of the second modulation are adequately suppressed. Pre-emphasis of the carrier signal according to the characteristic shown in Figure 6 is now introduced. To guard against television signal energy, which may be present at the extreme of the partially shaped vestigial region, from interfering with the 64-kc pilot regulation channel and the 80–88-kc sound program channel, a band elimination filter is provided.

The considerable phase distortion, which is inherent in the vestigial shaping process as well as the sum of small residuals present throughout the transmitting terminal, is equalized in the following phase equalizer as indicated.

To assure an adequate level of the carrier signal for application to the *L-1* coaxial line, an amplifier is finally provided. This amplifier is of a 3-stage feedback type employing common cathode impedance of a form such that the feedback is maintained at a high value for the lower frequencies where the higher signal energy condition obtains. This type of feedback amplifier design also exhibits improved stability under conditions of variations in internal gain such as caused by aging of vacuum tubes and variation of other elements.

The networks previously referred to, the band-filter, low-pass filter, pre-emphasis network, band elimination filter, and phase and attenuation equalizers, represent the major contribution to the shaping and control of the transmission band characteristic of this vestigial sideband carrier terminal. Accordingly, to meet the severe television transmission requirements adequately, these networks must not only embody precise design techniques, but must also be capable of exact control and adjustment during manu-

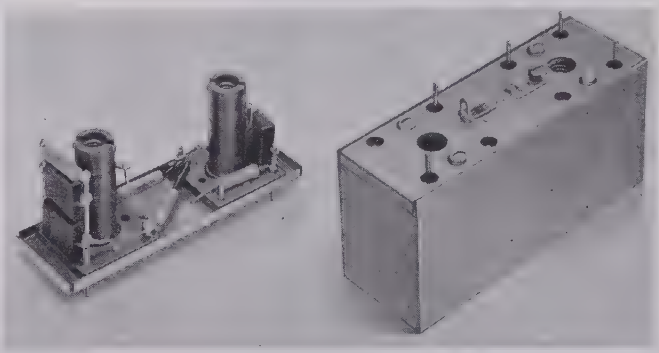


Figure 9. Typical equalizer section—mechanical arrangement

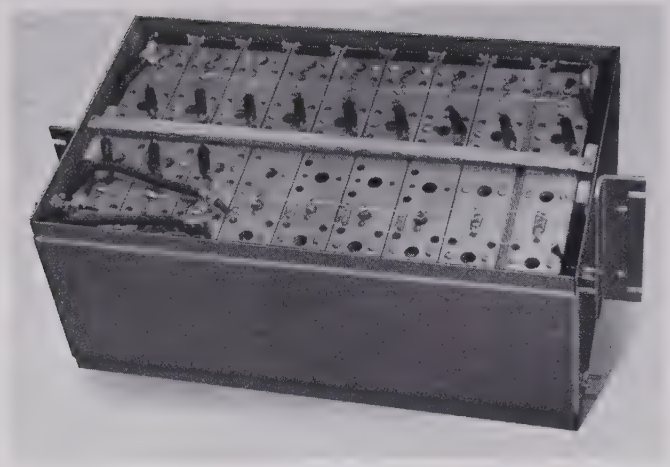


Figure 10. Typical network assembly—mechanical arrangement

facture and must maintain their performance over the life of the terminal equipment under all operating conditions.

To achieve this admittedly exacting performance standard it has been found necessary to develop some new type network elements as well as more precise methods of construction and assembly. A new series of retardation coil types is employed featuring metallic slugs for inductance adjustment. These elements are available in a continuous range of inductance from 0.22 to 220 microhenries. The form of these coils is designed for ease in mechanical assembly, and to assure a minimum of parasitic effects. Figure 9 shows the mechanical features of a typical constant resistance equalizer section employing these elements. Other elements shown include silvered mica-type capacitors and carbon deposited on glass-type resistors.

All networks in the transmitting terminal are enclosed in a single hermetically sealed case. Figure 10 indicates the method of assembly of the individual network sections into the complete circuit. In this particular unit, 43 coils, 68 capacitors, and 41 resistors are involved.

Figure 11 shows a complete television transmitting terminal for the *L-1* coaxial system. This terminal occupies approximately three feet of relay rack space. Included here is a regulated rectifier-type power supply which operates from 115-volt 60-cycle power, to furnish the necessary d-c plate voltages for the entire terminal.

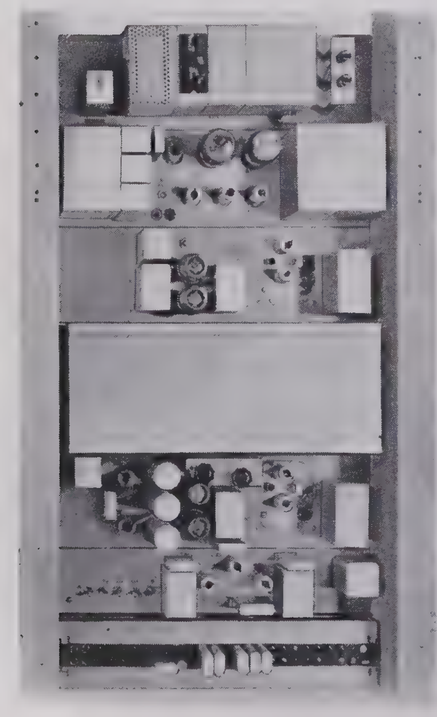


Figure 11. L-1 coaxial television transmitting terminal—bay arrangement

RECEIVING TERMINAL EQUIPMENT

A block schematic of the elements of the *L-1* coaxial television receiving terminal is shown in Figure 12. The receiving terminal recovers the video signal from the received carrier signal as transmitted over the coaxial line. The modulation methods involved were discussed previously and are shown in Figure 2.

The pilot frequencies at 556, 2,064, and 3,096 kc which are transmitted over the coaxial line for gain regulation purposes must here be reduced in amplitude to assure noninterference with the television signal. A simplified schematic of the pilot elimination network is given in Figure 13. The operation of this circuit is based upon the condition of infinite attenuation presented between two windings of a hybrid coil when the remaining two windings are terminated in equal impedances. In this instance, one winding of the hybrid coil is terminated in a resistance. The associated winding is terminated by a transformer and three crystal filter networks as shown. At the resonance frequency of each crystal network, the impedance of the array, as presented at the terminals of the hybrid coil, is adjusted to be equal to the resistance termination of the associated winding. In these three very narrow frequency regions, located to coincide with the pilot tones, high attenuation is introduced within the signal branch of the hybrid coil. To assure coincidence of the resultant attenuation band and the pilot tone, the elements of the crystal networks are maintained at a constant temperature by means of a thermostatically controlled oven.

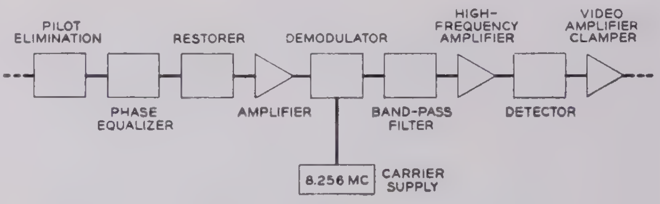


Figure 12. L-1 coaxial television receiving terminal—block schematic

The effective band elimination width is approximately 20 cycles at 556 kc, 60 cycles at 2,064 kc, and 100 cycles at 3,096 kc. Figure 14 shows some of the constructional features of the pilot elimination network.

The function of the phase equalizer following the pilot elimination network as shown in Figure 12 is similar to that previously discussed in the transmitting terminal. The band elimination filter here provides the necessary discrimination to the 64-kc pilot tone and to the 80–88 kc car-

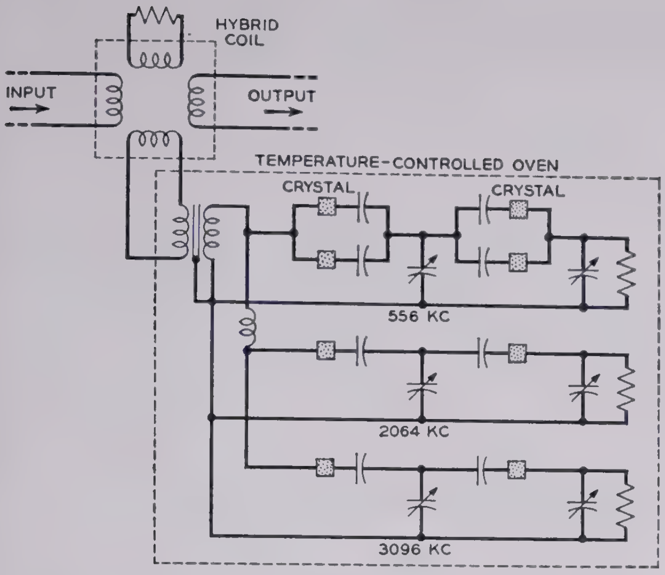


Figure 13. Pilot elimination filter—simplified schematic

rier sound channel. The restorer network characteristic has been previously indicated in Figure 6.

The following amplifier is identical to that described in the transmitting terminal. The demodulator which follows is supplied with a carrier frequency of 8.256 megacycles and provides the method by which the carrier signal as received from the coaxial line is again modulated into the 5- to 8-megacycle region. This demodulator is of the balanced type with conjugate carrier excitation as in the transmitting terminal. This is required to reduce the carrier leak and unwanted second order modulation products to noninterfering levels.

The lower sideband of this modulation process is selected by the following band filter where the remainder of the vestigial sideband shaping is accomplished. This filter is identical to the band filter similarly employed in the transmitting terminal.

To provide an adequate level of this carrier signal for final envelope detection, an amplifier is provided furnishing approximately 31 decibels of gain in the 5- to 8-megacycle frequency band. This amplifier is also of a 3-stage feedback type. The schematic of the envelope detection circuit is shown in Figure 15. The modulated carrier signal with the carrier located at 7.944 megacycles, with the main sideband extending downward to approximately 5.1 megacycles and with the vestigial sideband extending upward to approximately 8.056 megacycles is impressed upon a bridge rectifier circuit. The nonlinear elements of this detector are germanium crystals. The rectified video signal output is then amplified and clamped prior to delivery to the receiving network operating center.

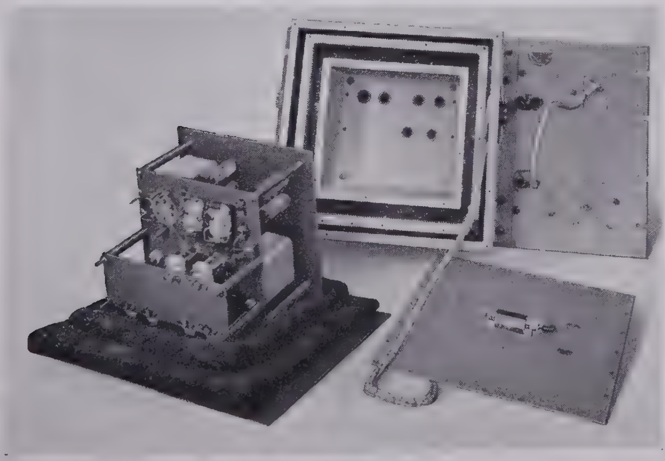


Figure 14. Pilot elimination filter—details of construction

The theory of design and operation of clampers in television transmission has been presented recently. It is sufficient here to relate that the clamper, as employed in television transmission, periodically restores the video signal to a desired constant reference value. In this case this is done upon the arrival of each horizontal synchronizing pulse. In this manner very low frequency distortion or interference is effectively attenuated, the amount of attenuation being directly related to the ratio of the fundamental horizontal synchronizing frequency to the distortion frequency. A theoretical reduction of 31 decibels in a 60-cycle interference voltage may be obtained by this means.

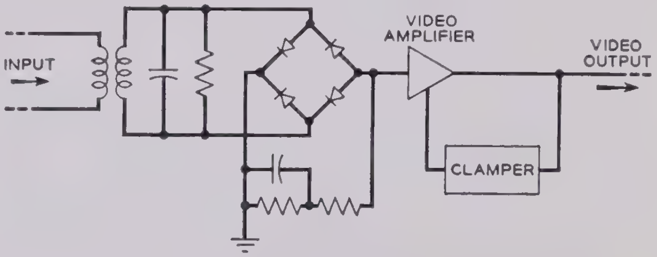


Figure 15. Envelope detector and video amplifier-clamper—simplified schematic

In the case of the *L-1* coaxial system this clamping action reduces the effects of any power frequency modulation of the carrier which may have been introduced during transmission over the line. The *L-1* coaxial television terminal equipment described here was developed following basic design principles established prior to the last war.

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Justification of Heaviside Methods

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THE METHODS of Heaviside for solving differential equations commonly arising in problems of engineering and physics, are of great value and are very widely used. However, Heaviside did not fully justify his methods, saying that "reservations should be learned by experience." Mathematicians, therefore, have generally preferred to approach the same goals by use of the Laplace transformation. However, the recent work of the French mathematician, Laurent Schwartz, provides justification of Heaviside's methods, and opens the way to their wider use.

Two concepts are presented in this article. First, it is pointed out that differentiation is not generally the inverse of integration. This is a barrier that prevents the free use of operational methods, and it also requires extra steps to determine the constants of integration. It is then shown that differentiation and integration become commutative if the function vanishes at the lower limit of integration, and that this can always be secured by the use, as a "cutoff," of Heaviside's unit function H where

$$\begin{aligned} 1 = H(t, t_0) &= 0 \text{ if } t<t_0 \\ &= 1 \text{ if } t>t_0 \end{aligned} \tag{1}$$

Multiplying all values in the differential equation by H assures that the quantities vanish when $t < t_0$. Difficulties arise, however, when the derivatives of the unit function appear, which are zero everywhere except at $t=t_0$, where they do not exist in a mathematical sense.

Second, to solve this problem, the Schwartz method of representing a discontinuous function as a "distribution in mass space" enables multiple differentiations to be performed on the distribution, giving a finite result. Thus, the desired operations are carried through in "mass space," and all dealings with infinity are avoided. This method of Schwartz gives equations in mass space exactly parallel to those of the Heaviside method using H and its derivatives, and may be construed to justify the Heaviside results.

Schwartz considers a set of continuous infinitely differentiable functions that are zero outside of a finite interval, that is, functions $\phi(t)$, such that

$$\phi(t)=0 \text{ if } t<-k_1;\ \phi(t)=0 \text{ if } t>+k_2 \tag{2}$$

He multiplies the function $f(t)$ with which it is desired to deal, by $\phi(t)$, and integrates from $-\infty$ to ∞, calling the result a "functional," $f(\phi)$.

$$f(\phi)=\int_{-\infty}^{\infty} f(t)\phi(t)dt \tag{3}$$

Then $f(\phi)$ is the representation of $f(t)$ in mass space, where $\phi(t)$ is any function satisfying the conditions stated in the foregoing. Inversely, if the right-hand side is obtained as the representation in mass space, then the function it represents is $f(t)$. Similarly, replacing f by f', the representation of the derivative in mass space, if f' exists, is

$$f'(\phi)=\int_{-\infty}^{\infty} f'(t)\phi(t)dt \tag{4}$$

Integrating equation 4 by parts, we obtain

$$\int_{-\infty}^{\infty} f'(t)\phi(t)dt=[f(t)\phi'(t)]_{-\infty}^{\infty}-\int_{-\infty}^{\infty} f(t)\phi'(t)dt \tag{5}$$

By equation 2, however, $\phi(t)=0$ at both ∞ and $-\infty$, so that the first term on the right hand side of equation 5 drops out, leaving

$$\int_{-\infty}^{\infty} f'(t)\phi(t)dt=-\int_{-\infty}^{\infty} f(t)\phi'(t)dt \text{ or } f'(\phi)=-f(\phi') \tag{6}$$

Equation 4 holds not only when $f(t)$ is continuous but also when it is discontinuous. As an example we may find the representation $\delta(\phi)$ of the Dirac function $\delta(t)$ in mass space. Putting H for $f(t)$ in equation 4 we have

$$\delta(\phi)=H'(\phi)=-H(\phi')=-\int_{-\infty}^{\infty} H(t)\phi'(t)dt=-\int_{0}^{\infty} \phi'(t)dt=\phi(0) \tag{7}$$

This is the same result that is obtained if $f(t)$ is put equal to H, so that $df(t)=dH$ has the value unity (unit mass) at the origin and zero elsewhere, and the integration carried out. Thus the Dirac function is represented in mass space by $\phi(0)$ and it also corresponds to a unit mass dH placed at the origin. Similarly, we find that $-\delta'(\phi)=\phi'(0)$, and $(-1)^n\delta^{(n-1)}\phi=\phi^{(n-1)}(0)$. Schwartz then shows that $\phi'(0)$ can be interpreted as a unit doublet at the origin and gives similar interpretations for $\phi''(0)\ \ldots\ \phi^{(n)}(0)$.

Since engineers are better acquainted with the Riemann integral, it may be of interest to indicate how Heaviside's use of the impulse function or its equivalent, the Dirac function, would give the same result, subject, of course, to the limitation that some of the steps may not exist in the strict mathematical sense. In this case, we would write $\delta(t)$ for $f(t)$ in equation 3 and obtain

$$\delta(\phi)=\int_{-\infty}^{\infty} \delta(t)\phi(t)dt=\phi(0) \tag{8}$$

on making the usual assumption that $\delta(t)$ is zero everywhere except at $t=0$ where it is infinite in such a manner that its integral from $0-\epsilon$ to $0+\epsilon$ is equal to unity.

An nth order differential equation in which H and its n derivatives, H', H'', $\ldots H^n$, or their mass representations, occur can be separated into n independent equations, formed by equating the coefficients of H, H', H'', $\ldots H^n$, separately to zero. This leads to the Heaviside expansion theorem.

Digest of paper **49-184**, "A Derivation of Heaviside's Operational Calculus Based on the Generalized Functions of Schwartz," recommended by the AIEE Committee on Basic Sciences and approved by the AIEE Technical Program Committee for presentation at the AIEE Summer General Meeting, Swampscott, Mass., June 20–24, 1949. Scheduled for publication in AIEE *Transactions*, volume 68, 1949.

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Transformer Heating Under Short-Circuit Conditions

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THE TEMPERATURE LIMIT under short-circuit conditions has been 250 degrees centigrade for power transformers for many years. This temperature has been calculated assuming that all of the heat during the short circuit has been stored in the copper. There is good reason to believe that a temperature of 250 degrees centigrade is seldom reached under short circuit; first, because some of the heat is conducted to the turn insulation; second, full voltage is not maintained unless the kilovolt-ampere capacity of the transformer is small in comparison with the source of power; and third, the protective relay usually comes into action before the time limit is reached.

A series of tests made on three windings of the disk coil type with different amounts of turn insulation showed that the ultimate temperature rises are 20 to 30 per cent lower than calculated values based on the assumption that all heat is stored in the copper. As the windings heat up, the insulation absorbs a certain amount of heat and transfers it to the oil film around the windings. After the fault is removed, the temperature gradient in the insulation readjusts itself from heating to cooling conditions and the time constant, which is largely governed by insulation thermal resistance, determines the rate of cooling and the length of time the insulation stays at high temperatures.

It has been the general understanding that duration of the short circuit and ultimate temperatures reached in the heating cycle are the most important factors in determining the loss of tensile strength of the insulation. Less than ten per cent of the aging of the insulation occurs during the heating periods on windings of typical design and for all practical purposes, the temperature maintained during the slow cooling period is far more important than the maximum copper temperature attained up to the time the fault is removed. The AIEE Subcommittee on Neutral Grounding Devices recognized in 1946 that the temperature limits for a fault of one minute's duration or less should be a function of the rate of cooling alone and established standards for allowable temperature rises versus minimum cooling rates in AIEE Standard 32, Table 32.11 B.

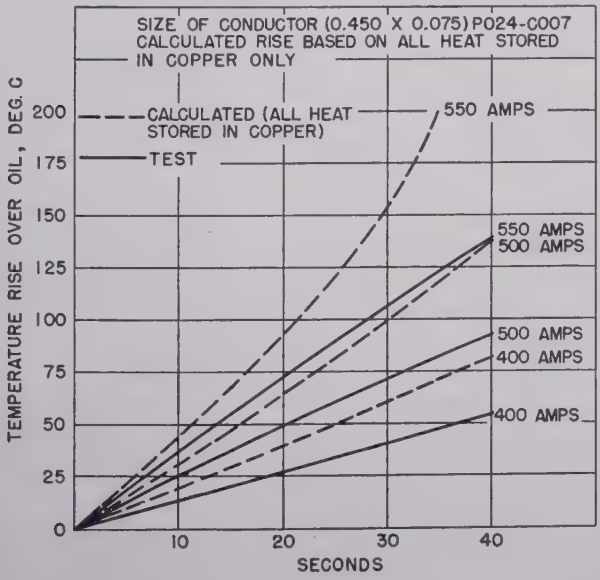

Figure 1. Curves of tested and calculated temperature rises during 40-second duration in 30-degree centigrade oil

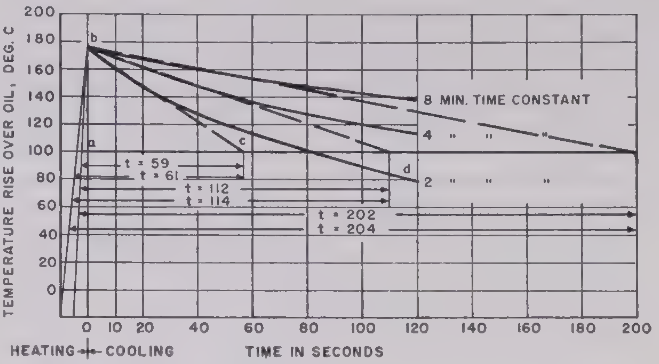

Figure 2. Curves showing heating and cooling of windings with 2-, 4-, and 8-minute time constants at 250 degrees centigrade (or approximately 4, 8, and 15 minutes at 95 degrees centigrade)

While the time constants of power transformers do not vary over the wide range that applies to grounding transformers, they do vary sufficiently to justify establishment of a range of permissible temperature limits calculated on a rational basis allowing for storage of heat in the insulation. The time constant ranges from 3 to 15 minutes for most transformer windings at normal operating temperatures and is reduced to 60 to 70 per cent of these values for short-circuit temperatures.

A simple formula which fits the test data assumes the thermal capacity of insulation per unit volume to be 67 per cent of the thermal capacity per unit volume of copper and allows easy calculation of ultimate temperatures. It is not as cumbersome to use as the present formulas in the ASA C57 Standards for Transformers, Regulators, and Reactors. The formula also uses an approximate method of including eddy loss. For a bare conductor with zero eddy loss, the formula checks the more accurate ASA formula. If an allowance is made for storage of heat in the conductor insulation, the permissible temperature should be reduced to obtain approximately the same temperatures as has been attained in the past.

Digest of paper **49-189**, "Heating of Transformers Under Short-Circuit Conditions," recommended by the AIEE Committee on Transformers and approved by the AIEE Technical Program Committee for presentation at the AIEE Summer General Meeting Swampscott, Mass, June 20–24, 1949. Scheduled for publication in AIEE *Transactions*, volume 68, 1949.

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Power Transmission in Northern California

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THE HISTORY of power transmission in northern and central California and the interconnection of hydroelectric and steam-electric plants dates back to just before the turn of the century. Development of water power was given impetus by the earlier uses of water in mining operations. The availability of petroleum fuels encouraged construction of steam plants in areas lacking in hydro power, or where it was needed for purposes of assuring the power supply in low water periods, or in case of interruption of long transmission circuits.

The development of hydro- and fuel-electric power facilities proceeded rapidly from the early beginnings. Successively higher transmission voltages were used to transmit larger blocks of power greater distances. During the war the construction of new lines and power plants was necessarily held to a minimum. But, in common with other West Coast areas, the northern and central part of California, largely served by the Pacific Gas and Electric Company, has experienced a substantial increase in population and power consumption during and following the war period. To meet the needs of the area an extensive program of hydroelectric and steam plant construction is underway.

The design of the high-voltage transmission system to interconnect new generating plants with the system is an important and distinct phase of system planning for the expansion program planned for 1946 through 1951. While the general location of hydro plants is fixed by natural conditions, there is some latitude in selection of new steam plant locations. An effectively arranged transmission system is required to co-ordinate the power capabilities of all sources in relation to the loads to be served. By a properly designed transmission the amount of spinning reserves necessary is held to a minimum; the quality and continuity of service is improved, and new generation is given an efficient outlet. Certain general considerations in transmission planning apply almost universally. Other factors are peculiar to the locality and may result in design features totally inappropriate for other areas.

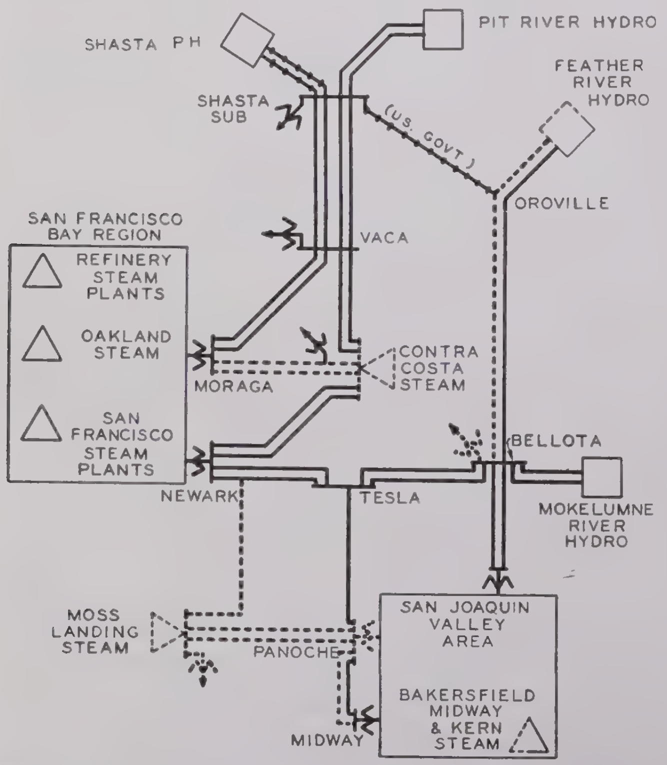

Figure 1. Schematic diagram of Pacific Gas and Electric Company

230-kv transmission and interconnections with Shasta powerhouse, 1948
Proposed additions through 1951 dotted

On the Pacific system the main bulk power transmission is by double-circuit 230-kv steel tower lines. Double-circuit construction has proved more economical than single-circuit design and has given very satisfactory operation. Overhead ground wires, not used on any early lines, have been installed in certain instances recently.

The 230-kv system is being extended to form a network of many hundreds of miles of circuit. The seasonal and daily variations in power flow over this network result in problems of voltage and reactive control which are being solved by applications of synchronous condensers, shunt reactors, and regulating transformers. Synchronous condensers are applied on the tertiary windings of autotransformers which are used for ties to the 115-kv network.

The heavy power concentrations resulting from extensive interconnection of hydro and steam plants have produced high short-circuit interrupting duties. High capacity circuit breakers are planned for new installations on the 230-kv system. An important feature of the 230-kv system is the use of high-speed relaying and the planned application of high-speed reclosing of lines.

In the postwar transmission program major 230-kv lines have been completed to the San Francisco Bay region from the northern hydro sources and from a new steam plant in the extreme southern part of the territory. Other high-voltage lines are planned and under construction from new hydroelectric plants on the Feather River and from two new steam plants, one on Monterey Bay and the other at the confluence of the San Joaquin and Sacramento Rivers on the upper branch of San Francisco Bay. New steam generation in San Francisco has been tied into transmission and distribution outlets by 115-kv high-pressure gas pipe-type cables. Several new 230-kv substations have been built, and additions made to existing substations.

Digest of paper **49-200**, "Postwar Planning for High-Voltage Transmission in Northern California," recommended by the AIEE Committee on Transmission and Distribution and approved by the AIEE Technical Program Committee for presentation at the AIEE Pacific General Meeting, San Francisco, Calif., August 23–26, 1949. Not scheduled for publication in AIEE *Transactions*.

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Cable Accessory Design Utilizing New Laboratory Techniques

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The development of new laboratory techniques has made the task of designing accessories for power transmission cable systems easier and more accurate. The electrolytic field analyzer has been used in the plot of fields in cable joints and oil ducts, and ultrasonic tests of bonded laminations have been made.

IN RECENT years the introduction of high-pressure fluid-filled cable systems for power transmission and the trend toward higher voltages have posed new problems in the design and construction of cable joints and potheads. Certain laboratory techniques have contributed much to the solution of these problems by providing the designer with accurate information and the producer with dependable test methods.

Adequate mechanical strength and easy field assembly must be achieved without sacrificing economy. Joints in particular must be designed to the smallest possible dimensions since they are the principal factor in determining costs of manholes in underground installations. The proper electrical strength must be obtained by good stress control and the use of modern dielectric materials. Laboratory methods have helped particularly to satisfy the electrical requirements although these, in turn, stem largely from mechanical considerations.

Before discussing methods of testing and development on cable accessories, a general description will be given of certain modern high-voltage cable accessories.

JOINTS AND POTHEADS FOR MODERN CABLE SYSTEMS

Cable systems may be classified according to the operating pressure of the filling medium as low, medium, intermediate, or high pressure. Oil-filled systems may be either low-pressure or high-pressure systems. Gas-filled systems may be any of these classes. Nominal pressure ranges which apply in each case are as follows:

	Pounds Per Square Inch Gauge
Low pressure	0–15
Medium pressure	35–45
Intermediate pressure	100–150
High pressure	180–225

In addition to being either gas- or oil-filled, high-pressure systems may be referred to as self-contained and pipe-cable systems.

The difference in these two types of high-pressure systems basically rests with the fact that the self-contained cable contains a filling medium under pressure from the time it leaves the factory. The pipe-cable is shipped from the factory with a protective jacket and is pressurized after it has been pulled into the steel pipe and the pipe is filled with the filling medium.

Cable Potheads and Joints. A pothead is a device for terminating the end of a cable so that it can be used for power transmission.

Joints in a cable system are used to join together two lengths of cable. The simplest type of joint is the normal joint. Special conditions require variations and complications in jointing procedure. Low-pressure oil-filled cable lines often follow a profile with considerable variations in elevation along its length. Static oil pressures may develop which will expand or burst the lead sheath due to these differences in elevation. Stop joints then may be furnished to sectionalize the cable oil supply so that excessive static pressures do not appear. A stop joint connects two cable ends together but at the same time contains an oil barrier to separate the oil supplies of the two cable ends being joined.

In high-pressure systems the static pressure problem is not present. Stop joints may be used, however, to help control the filling medium and prevent large oil or gas losses under fault or repair conditions. Occasionally it is necessary to join a high-pressure system to a low-pressure system and this requires separation of the two pressure mediums.

In general, stop joints are not common on gas-filled systems. Each layout must be considered on its own merits.

Potheads for High-Pressure Systems. Figure 1 shows representative potheads for a 115-kv high-pressure cable system. Figure 1*A* shows the pothead as used for a self-contained cable system with an outer lead sheath over the re-enforcing tapes. The pothead design is a practical correlation of three sections, the high-pressure section, the low-pressure section, and the electrical stress control section which physically involves portions of the other two sections.

The high-pressure section includes the high-pressure self-contained cable entrance with a double re-enforced wipe shown at *A*, the nonmagnetic support casting *B*, and the stop tube *C*. This last unit is a cylinder made by laminating paper impregnated with resin. It is characterized by high mechanical as well as electrical strength and is used here to seal the high-pressure fluid from the porcelain.

The low-pressure section consists of the compartment

Full text of paper **49-266**, "Cable Accessory Design Utilizing New Laboratory Techniques," recommended by the AIEE Committee on Insulated Conductors and approved by the AIEE Technical Program Committee for presentation at the AIEE Fall General Meeting, Cincinnati, Ohio, October 17–21, 1949. Scheduled for publication in AIEE *Transactions*, volume 68, 1949.

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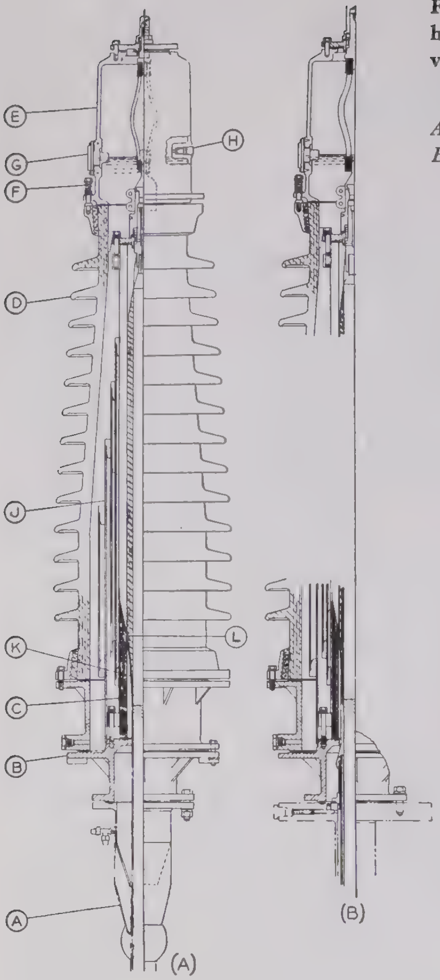


Figure 1. Pothead for high-pressure high-voltage cable termination

A—For self-contained cable
B—For pipe cable

outside the pressure cylinder and inside the enclosing porcelain shell *D* and the dome *E*. This section is designed to operate at a gauge pressure which would equal 10 pounds per square inch at a temperature of 75 degrees centigrade and in any case would not exceed 100 pounds per square inch. A pressure relief feature is afforded by the use of the springs *F* to maintain pressure on the gasket seal between the dome and the top of the porcelain. The whole dome will lift at some pressure between 50 and 100 pounds per square inch and reseal when the pressure returns to its normal range. This is provided to protect the low-pressure section from a leak in the high-pressure section. Pressure changes due to normal temperature variations in the low-pressure section are accommodated, without lifting the seal, by an expansion chamber in the dome. The dome, also contains an oil-level gauge *G* and an outlet *H* for treating and filling. The large oil volume in the low-pressure section is broken up as shown at *J* by cylindrical barriers spaced around the stop tube to increase the electrical strength.

This description has been given on the basis of a pothead being installed on a high-pressure self-contained cable. When the pothead is used on a high-pressure pipe cable system, the double wipe at *A* and the wiping sleeve are omitted and the pothead is adapted for mounting directly to a plate on the pipe riser. This construction is shown in Figure 1*B*. Except for this mounting provision, the pothead may be the same for both applications.

The function of the stress control section is the termination of the cable ground shield in a way which will avoid setting up dangerous electrical stresses. In the cable proper a high voltage is supported across a relatively narrow insulation space between the conductor and shield because the electric field is uniform and radial, that is, at right angles to the paper layers. At the pothead the ground shield is tapered out gradually in region *K* in Figure 1*A* to the inner surface of the stop tube so as to keep the longitudinal stresses small. This insulation is built up by means of taping applied by hand over the regular cable insulation up to the inside of the ground shield and the stop tube. Its maximum diameter is made as large as is consistent with easy assembly to insure a tight fit against the inside of the stop tube. This is done to decrease the width and thus increase the electrical strength of the oil channel between the taped section and the tube.

At the line *L* where the ground shield meets the stop tube, the ground circuit is continued into the wall of the tube by means of a conducting impregnant. This is a conducting material which is sprayed on the paper as the tube is manufactured and which hardens so as to produce a tube with a built-in shield. It is shaped so as to terminate the ground shield in the wall of the stop tube where the electrical strength is high. The conducting impregnant is very useful in controlling stresses where properly applied. Its proper use is, however, greatly dependent on experience and improper application can do more harm than good. In this connection, as in any stress control problem, the electrolytic field-analyzer discussed later is of considerable help.

It is apparent that the stop tube is a critical component of the pothead assembly subjected to high stresses both mechanical and electrical. Its manufacture is carefully supervised and checked by electrical and ultrasonic tests.

Potheads for Low-Pressure Systems. A new low-pressure high-voltage power cable pothead of the solder seal[1] design is shown in Figure 2. A solder seal is made at each end of the porcelain to the metal parts at the factory. There are no gaskets in the complete pothead assembly; therefore there can be no leaks in service from that source. The mounting clamp location *B* is adjustable up and down the wiping sleeve assembly to compensate for variations in cable cut-off length and mounting heights.

This pothead differs further from the high-pressure pothead described previously in that the stop tube is eliminated and the pressure of the cable fluid is retained by the porcelain shell. The ground shield is tapered outward and the cable insulation built up as in the previous design. Since the stop tube is not used, the end of the ground shield is protected by a semiconducting cloth, *A* in Figure 2, whose resistance is chosen to cause a gradual voltage drop in an axial direction along the cloth and thereby reduce the stress at the end of the ground shield at both 60 cycles and impulse voltages.

Joints for High-Pressure Systems. For the purposes of this article the discussion of joints for high-pressure pipe cable systems will be limited to stop joints. A representative design of such a joint is shown in Figure 3*A*.

As mentioned previously, the stop joint separates the cable fluid in either side of the joint. This is accomplished by the use of a stop tube similar to that described in the discussion of the pothead. The two cable ends are brought in from either end of the joint to the connector at the center. The cable shield is cut back to the end of the ferrules, as shown at *A*, to give the required electrical creepage distance from the connector end to the grounded shield. As in the pothead, hand-applied tape wrappings then are built up over this cable end and over the connector to obtain a close fit to the inside of the stop tube. The high-pressure fluid from the pipe is admitted to the inside of this stop tube through the permeable tape and through the by-pass opening shown at *B*. This pressure is sealed inside this tube at the connector by the gaskets at *C* which are compressed against the connector and the tube by tightening the nuts at *D* on the connector. Thus the requirement is met in keeping the fluid on each side of the joint separated. It also can be seen that electrically the stop tube occupies the same critical position that it does in the pothead.

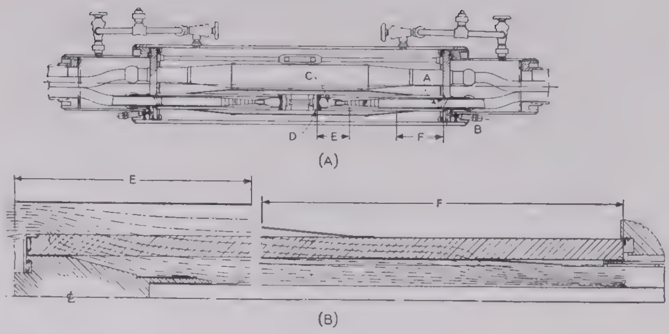


Figure 3. A stop joint for high-pressure pipe cable

A—Mechanical details
B—Electric field plot for regions E and F. The contours are equipotential lines spaced at intervals of ten per cent of the applied voltage

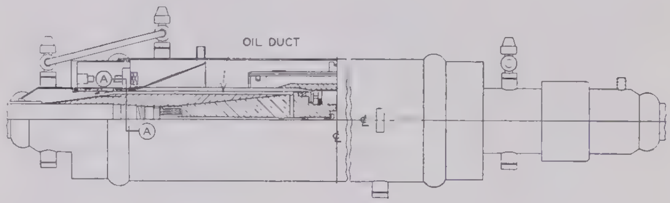


Figure 4. A new design stop joint for low-pressure oil-filled cable systems

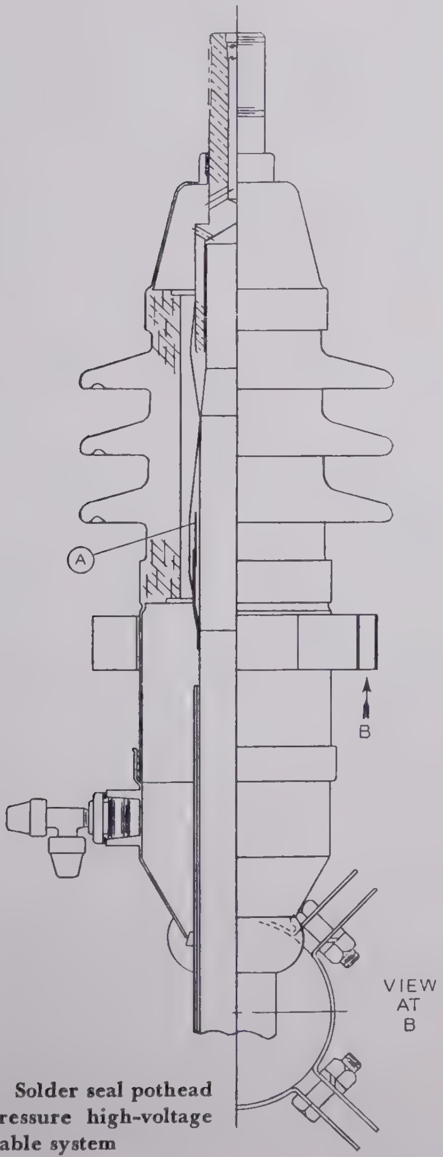


Figure 2. Solder seal pothead for low-pressure high-voltage cable system

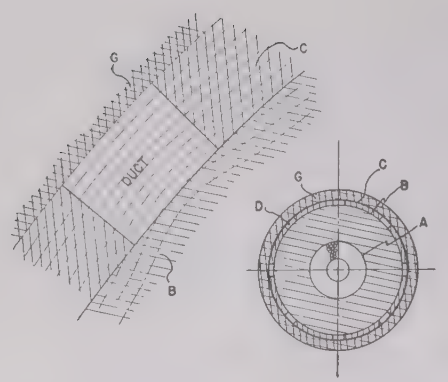
The stress control problem is somewhat simpler in the stop joint than in the pothead because the ground circuit is not terminated but is carried completely around the joint.

Joints for Low-Pressure Systems. A new design stop joint for low-pressure oil-filled cable systems may be seen in Figure 4.

The principal feature in this new design is the stop tube which replaces the molded cone-shape barrier used in older designs. A good quality tube made from resin-impregnated paper laminant is strong mechanically and electrically and permits cylindrical taping contours which are easily made during field assembly. This component is like that discussed for the high-pressure joint. However, this low-pressure joint is designed for 15 pounds per square inch gauge pressure, which means lighter-weight parts throughout and allows for a sizable saving in the cost of materials. It also is for use with hollow-core oil-filled cable so that provision is made for oil flow from the cable core up through radial holes in the connector half, and back through the longitudinal ducts under the stop tube. A discussion of the electric stresses in this duct area is given later in this article.

LABORATORY TECHNIQUES

The Electrolytic Field-Analyzer. An instrument of great help to the designer of high-voltage cable accessories is the electrolytic field-analyzer, which provides accurate answers to stress problems whose solution by numerical or graphical methods may be laborious or unreliable. This device, also called electrolytic tank, electrolytic bath, and electrolytic flux plotter, is based on the analogy between the voltage field in a dielectric and that in an electrolyte. Al-



A—Cable conductor
B—Paper insulation
C—Pressboard spacer
D—Fluid duct
G—Ground shield formed by conducting on portion of stop tube

Figure 5. Fluid ducts in a stop joint; (left) field plot in region of one duct, (right) mechanical details

though the principle is familiar to many engineers it has not, perhaps, been sufficiently exploited.

In order to measure voltage stresses with this instrument, a model of the equipment to be analyzed is constructed using electrolytes of different depths or conductivities to represent different dielectrics. The voltages in the model are recorded on paper as a series of equipotential lines or voltage contours whose spacing determines the electrical stress or gradient in each region. Field plots obtained in this way have been applied to the design of high-voltage cable accessories to improve construction, to predict the voltage level and location of insulation failure, to assess the value of high-voltage tests, and as an educational aid.

Analysis of Electric Fields in Cable Joints. Figure 3*B* is a field plot, made by means of an electrolytic field-analyzer, which shows the voltage distribution in a high-voltage high-pressure cable stop joint. The contour lines are traces of surfaces of constant voltage drawn at intervals of ten per cent of the total voltage. As all the insulating materials are laminated cylindrically, the electrical strength is high in a radial direction. The important quantity is, therefore, the component of stress in the direction of the cable axis, because this stress acts to cause failure along the laminations in which direction the electrical strength is lowest. It would be expected, for example, that failure would occur first along the outer surface of the laminated stop tube in region *G* of Figure 3*B* since the spacing of the equipotential lines along the surface of the stop tube is closest in this region. By measuring this spacing on the field plot, it is possible to calculate the maximum stress in kilovolts per inch along either surface of the stop tube for any voltage applied to the cable joint.

Table I. Breakdown Stresses for Stop Joints

Design	Applied Potential at Failure Under Impulse Test Kilovolts	Maximum Stress Along Stop Tube Surface at Failure, Kilovolts Per Inch	
		Inner Surface	Outer Surface
A	325	139*	33
B	210	160	680*
C	350	140*	350
D	above 700	above 49	above 140

* Indicates location of failure.

This was done for a series of high-voltage high-pressure gas-filled stop joints of different designs, one of which is that shown in Figure 3*A*. These units also were given high potential tests under impulse conditions using the standard 1.5 by 40 microsecond wave. The crest value of the impulse wave sufficient to cause failure is given in Table I for each of the designs except for *D* which was subjected to 700 kv without failure. The maximum stress or voltage gradient to which each surface of the stop tube was subjected at the crest of the wave also is listed in the table.

It will be seen that two of the joints failed along the inner surface when the stress in that region reached about 140 kv per inch. The other two did not fail along the inner surface but were subjected to 49 and 160 kv per inch respectively. This implies that the average electrical creepage strength along the inner surface of all four stop tubes is about 150 kv per inch. Failure occurred along the outer stop-tube surface in only one joint and this was at a stress of 680 kv per inch. None of the other stop tubes were subjected to this stress although the outer surface of one reached 350 kv per inch without failure. Thus, the outer surface of the stop tube appears to be at least four times as strong for creepage as the inner surface. This may be explained by the fact that it is possible to wrap the tape much closer to the outer surface. In any case, the designer must take particular care to keep the stresses small along the inner surface of the stop tube. Design *D*, which shows very low stresses even at 700 kv, was developed after a study of field plots and high-potential tests on units *A*, *B*, and *C*. This illustrates what can be accomplished by careful design guided by results obtained from the field-analyzer.

Field Stresses in Oil Ducts. The electrolytic field-analyzer also has been applied to the study of electrical stresses in the ducts used in cable stop joints to introduce the cable fluid. As indicated in Figure 4, these ducts run parallel to the cable axis between the inside of the stop tube and the outside of the built-up taping. They are formed by pressboard spacers which also run lengthwise along the inside of the stop tube. Figure 5 shows a field plot and the mechanical arrangement of the ducts at section *AA* of Figure 4. The field plot indicates that the maximum stress appears across the center of the duct. The voltage drop across this space is plotted in Figure 6 for joints with ducts of constant height but varying in number and width. The solid curve was obtained with four ducts by varying the width of the individual ducts. For the dotted curve the total duct area was varied by adding spacers of constant one-half inch width so as to change both the size and the number of ducts.

These curves show that the stress increases with the duct area. Comparison of the ordinates of the two curves taken at the same abscissa, however, shows the decrease in stress obtained, for a given total duct area, by breaking this area up into a number of smaller ducts.

This oil duct study illustrates the value of the field-analyzer as an educational device. Before the field plots were obtained, a fear was expressed that the abrupt change in dielectric constant across the radial wall of the duct might lead to excessive electrical stresses. The smooth flow of the voltage contour lines across the boundary, is convincingly shown by the field plot which indicates that no excessive stresses occur at the walls of the duct.

High-Voltage Testing of Stop Tubes. In order to subject stop tubes to a high-potential test before assembly, a high 60-cycle voltage is applied to a tube immersed in oil with electrodes connected to opposite ends. To evaluate this test, field plots were made of the test setup and of the assembled pothead. These plots showed that the electrical stresses on the stop tube under high-potential test were much different from those in the assembled pothead at the same applied voltage. Practically, it is difficult to arrange a high-potential test that will not be unrealistic in the sense that the tube is overstressed in some regions and understressed in others. Furthermore, a high-potential test of one minute duration is not equivalent to long-time operation at normal voltage. These considerations have led to the adoption of additional tests on stop tubes.

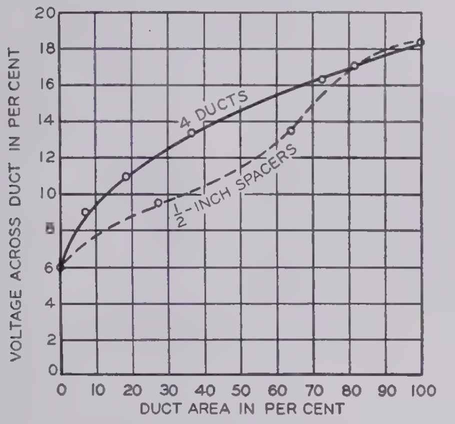


Figure 6. Electrical stresses in oil ducts, a résumé of data obtained from field plots like that of Figure 5

Ordinate is the voltage across the duct expressed in per cent of the total voltage applied to the stop joint. Abscissa is the actual duct area expressed as per cent of the total available annular area for fixed duct height

The Ultrasonic Transmission Test. One of the most important factors affecting life and dielectric strength of solid laminated insulating materials is the possibility of small openings or poor bond between laminations. Cylinders of moderate wall thickness can be fabricated with considerable assurance that they will be free of such defects. Stop tubes used in high-pressure cable systems, however, may have a wall thickness of as much as one inch. They are, consequently, much more difficult to manufacture without defects. Because of the high mechanical stresses as well as for electrical reasons, a sensitive test for the detection of poorly bonded areas in such cylinders is particularly desirable. Such a test makes it possible to reject weak materials before assembly and aids in the development of improved materials.

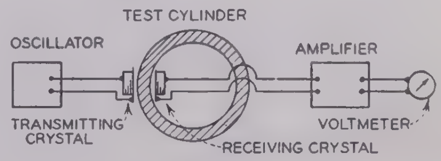
The measurement of the transmission characteristics of a material for ultrasonic waves constitutes one such test. When a very-high-frequency sound wave is sent through a homogeneous material of moderate thickness in a direction perpendicular to the plane of the laminations, it emerges from the far side with little decrease in amplitude. In a region where any laminations are not well impregnated or well bonded, however, the transmitted amplitude will drop sharply. This so-called ultrasonic transmission test is one of several familiar techniques[2] for applying ultrasonic waves to the examination of the interior of opaque materials. Its present interest lies in its use as an indication of dielectric strength.

The ultrasonic transmission test has been applied to pressure stop tubes used in cable joints and potheads. To insure that the material will be free of interior corona, this test seems to be superior to any other applicable to these units. A stop tube is subjected during operation to full line-to-ground voltage from end to end. Because poorly bonded laminations result in a weakness to voltage stress applied parallel to the laminations, their detection is more important in stop tubes than in materials subjected to purely radial stresses.

The test setup is shown schematically in Figure 7. An electric oscillator of frequency approximately one megacycle per second is used to drive a crystal transducer which converts electric into mechanical vibrations. After the waves pass through the wall of the test cylinder, a second transducer converts the energy back to electric oscillations that are amplified and read on an output meter. Transducers and test piece are immersed in ordinary transil oil, which is an efficient sound transmission medium and which obviates the necessity of direct contact between transducer and test cylinder. The use of high frequency and small crystals (about five-eighths inch square) results in a narrow beam of energy which permits the detection of flaws covering only small areas. The equipment is arranged to read transmitted amplitude as per cent of the value obtained when the beam passes directly through the oil with no test material in place. Paper laminates of good quality up to one inch in thickness made with a resin binder show transmissions in the range of 20 to 50 per cent of that for oil alone. Where there are any cracks or openings, however, the transmission usually falls to a value below one per cent. The cylinder may be scanned by dropping it one inch at a time and rotating it one revolution at each stop.

In order to establish the significance of the ultrasonic readings for dielectric materials, tests were made comparing dielectric strength with ultrasonic transmission. One-inch-long sections were cut from rejected stop tubes at interesting points where a careful ultrasonic check had been made. The resulting ring-shaped sections were given a 60-cycle voltage breakdown test between 12-inch diameter parallel-plate electrodes in transil oil at room temperature with voltage increasing at the rate of 3 kv per second. A uni-

Figure 7. Ultrasonic transmission test for laminated stop tubes



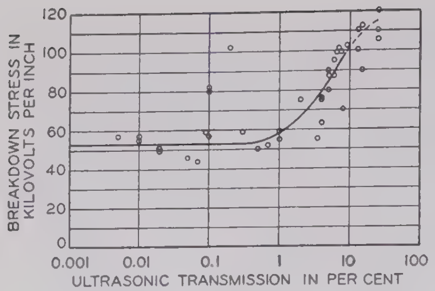


Figure 8. Experimental correlation between ultrasonic transmission through laminated stop tubes and electrical strength for breakdown parallel to the laminations

form stress was applied parallel to the laminations of the sample so as to induce breakdown along any openings between laminations. The end surfaces of the sample were given a thin coat of grease to exclude oil from such openings and maintain the conditions under which the ultrasonic test was made.

The ultrasonic transmission values were found to correlate well with both location and voltage level of the electrical failure. When the samples failed through the interior, it was usually in the region where the ultrasonic transmission was lowest. In Figure 8 the voltage at breakdown is plotted on a linear scale against the minimum value of ultrasonic transmission observed for each sample and plotted on a logarithmic scale. Most of the experimental points fall close to a curve which represents a constant dielectric strength of 53 kv rms per inch for ultrasonic transmission values in the range of 0.005 per cent to 1 per cent and then rises to about 110 kv per inch. At transmission readings around 10 per cent and above, the strength of the material is actually higher than that shown because the samples failed by flashover along the surface instead of through the interior.

The flat portion of the curve corresponding to very low transmission values represents breakdown through the air in an interior crack. The voltage of 53 kv per inch agrees with Peek's values[3] for breakdown in air between large spheres one inch apart. Those experimental points which are far from the curve probably represent samples in which the crack was not continuous from one side to the other.

It is evident that the ultrasonic transmission test can be very valuable as an indication of the dielectric strength of certain materials. The equipment is rather simple and involves no high-voltage hazard. The test is nondestructive and gives a localized reading for every region of a sample. Its principal disadvantage is that its application and interpretation is simple only for samples of simple shape such as cylinders and plate stock. For more complicated shapes the test may be impractical.

CONCLUSIONS

The foregoing discussion has indicated some of the mechanical problems of high-voltage high-pressure design of cable accessories and certain electrical problems which arise from the mechanical requirements and from the high voltage. Some of the laboratory techniques which help to solve the electrical problems were seen to be the electrolytic field-analyzer which helps the engineer to design apparatus with the lowest possible electrical stresses on the insulation and gives quantitative information as to the actual stresses that will exist in the completed equipment and the ultrasonic transmission test which provides a sensitive indication of the presence of flaws that would affect the dielectric strength of solid insulating materials.

It is felt that the engineer must be prepared to take advantage of such modern techniques in order to build high-voltage cable accessories which will be reliable and economical.

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3. Dielectric Phenomena in High Voltage Engineering (book), **F. W. Peek.** McGraw-Hill Book Company, New York, N. Y., third edition, 1929. Page 121, Table XXIII.

Compressed Air Drives Generator

Seated on a heavy steel protective barricade, Robert I. Strough, Case Institute of Technology physicist, adjusts his whirling-disk generator, which is capable of developing a magnetic field 6,000 times as great as that of the earth. Driven by a jet of compressed air, which whirls a flywheel at 17,000 rpm, the unique machine has "brushes" that are jets of liquid mercury and a rotor cast out of solid copper. Heart of Strough's generator is the $5^3/_4$-inch disk of beryllium-copper alloy. A stream of compressed air, blowing against "buckets" cut into the disk, turns it at speeds approaching 300 miles per hour. To prevent an accident, should the disk shatter, the machine is surrounded by a heavy barrier of timbers and steel. Possible application of this generator is as the magnetic core of a betatron or other atom-smasher.

Oscillographic Study of Hydroelectric Units

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A MAGNETIC oscillograph, with auxiliary equipment, has been found useful at the Grand Coulee Power Plant, Columbia Basin Project, for obtaining information about operating characteristics of hydroelectric units which cannot be obtained from the ordinary indicating and recording instruments. Quantities recorded include mechanical movement, hydraulic pressure, bearing loads, and turbine vibration and noise.

Records of this kind were needed to analyze the behavior of a large vertical generator shaft which was not running true. A special form of impedance bridge was built to serve as a pickup, that is, a device to transform mechanical movement into changes in electric energy. This type of pickup was chosen because it is simple and rugged, is easily matched to the recording instrument, and requires no mechanical connection to the moving member. In use, it is mounted close to the part being studied, so that any relative movement varies the reluctance of a magnetic circuit, and, consequently, varies the impedance of two diagonally opposite legs of the bridge. By applying a low alternating potential to two terminals, an a-c output is obtained from the mid-point which is proportional to the movement. Using four such pickups, the runout of the shaft at the top, bottom, and intermediate points was recorded simultaneously, and the necessary corrective measures ascertained.

The success of the method led to experiments in recording other quantities. By the addition of a Bourdon tube from an ordinary pressure gauge, the device was adapted to the measurement of hydraulic pressures, thus making it possible to examine turbine performance more exactly, and to measure penstock pressure changes caused by sudden load variations.

The ordinary radio loud-speaker of the permanent-magnet-field type serves very well for indicating relative vibration and noise. Definite data were thus secured on the effect of admitting air to the draft tube of a 150,000-horsepower turbine at various loads. Strain gauges, connected to form a Wheatstone bridge, are used in a way similar to the impedance bridge to record the load on individual segments of a Kingsbury-type thrust bearing. Thus, bearing performance can be closely checked, and additional stresses caused by hydraulic disturbances measured.

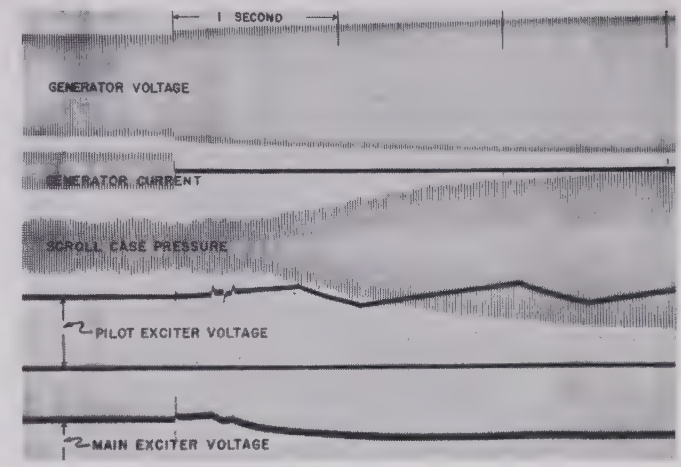

Figure 3. Record of pressure build-up in scroll case of 150,000-horsepower turbine in relation to generator electrical quantities during load rejection test

A number of oscillograms selected from the files of the Bureau of Reclamation illustrates the variety of information which can be readily recorded. It is hoped that these examples will be of benefit to operating and test engineers, and suggest other methods of obtaining useful data. The suitability of the oscillograph for testing electric circuits on all types of power equipment has long been recognized.

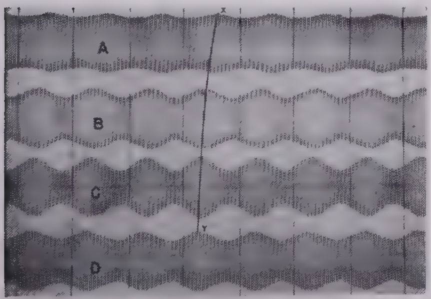

Figure 1. Typical record of large vertical shaft on 108,000-kw machine turning 120 rpm

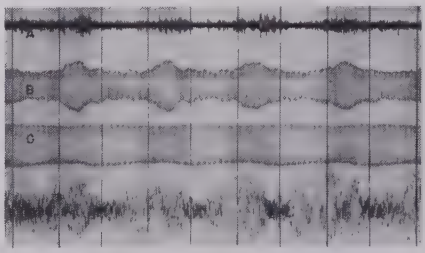

Figure 2. Record of the noise and vibration which is associated with pressure change in a hydraulic turbine operating under load

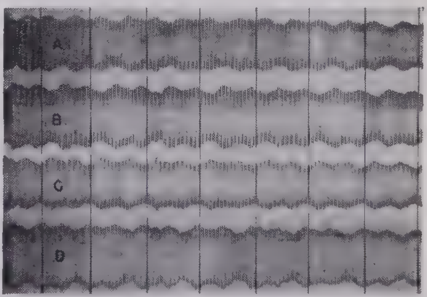

Figure 4. Record of load changes on alternate shoes of a Kingsbury-type thrust bearing

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Digest of paper **49-204**, "Some Oscillographic Methods of Investigating Mechanical and Hydraulic Conditions During Operation of Hydroelectric Units," recommended by the AIEE Committees on Instruments and Measurements and Power Generation and approved by the AIEE Technical Program Committee for presentation at the AIEE Pacific General Meeting, San Francisco, Calif., August 23–26, 1949. Scheduled for publication in AIEE *Transactions*, volume 68, 1949.

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Directional Current Circuit Protector

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IN MODERN AIRCRAFT the increasing use of electric equipment has increased the dependence of the aircraft on the electric system. To improve the reliability of this system additional fault protection is necessary.

Research and past experience has shown that the majority of the short circuits occurring in a 28-volt d-c system are self-clearing. However, in some instances the duration of a fault might be dangerously long, with some faults actually effecting a weld.

The protection of the 28-volt electric system, on a multiengine aircraft, from a faulted generator circuit requires a directional current circuit protector. After investigating the possible fault conditions a protector with the following requirements is believed necessary:

1. An inverse-time characteristic must be used to prevent false tripping and to allow a reasonable time for faults to self-clear if they will, thus keeping as much of the aircraft's electric system in operation as long as possible.
2. The protector should isolate the faulted generator circuit and at the same time open the generator field so that the generator cannot continue to supply power to the fault. The unit should permit resetting by hand.
3. The minimum trip current of the protector must be chosen to allow for normal reverse currents which are normally interrupted by the generator control relays.
4. The protector should have a high interrupting capacity. The exact value will vary for different aircraft systems. A value of 10,000 amperes was believed to be necessary for this protector.
5. The directional protector should not trip in the forward direction at currents less than 500 per cent rated generator output.
6. A vibration of 10 times the force of gravity at 3,300 cycles per minute should have no effect on the protector's operation.

During a lengthy period of experimentation and testing the directional current circuit protector shown in Figure 1 was evolved. The principle of bimetal heating is employed to obtain the inverse-time characteristic (Figure 2). The action of bimetal strips, being heated by radiant and conducted heat from a heater strip, is used to trip a spring-loaded linkage which operates to open the generator field and output circuits. The polarizing (to make the device unidirectional) of the directional circuit protector is accomplished by utilizing the motor action. That is, a magnetized Alnico rotor is supported in an electromagnetic field produced by the current flowing through a coil in the protector. Thus, the position of the rotor is dependent on the direction of the current flow through the protector.

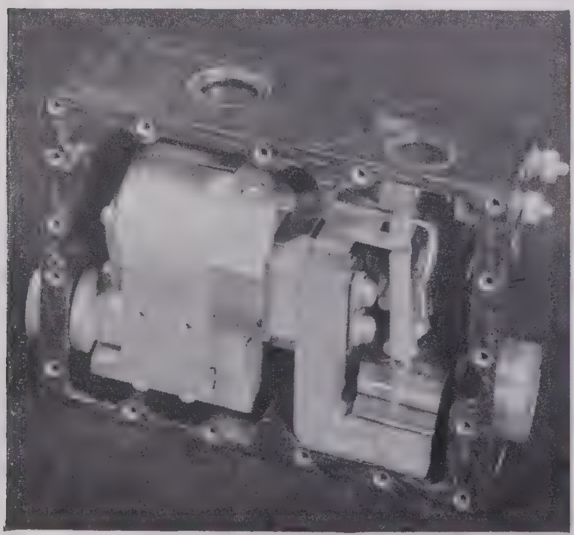

Figure 1. Production directional circuit protector

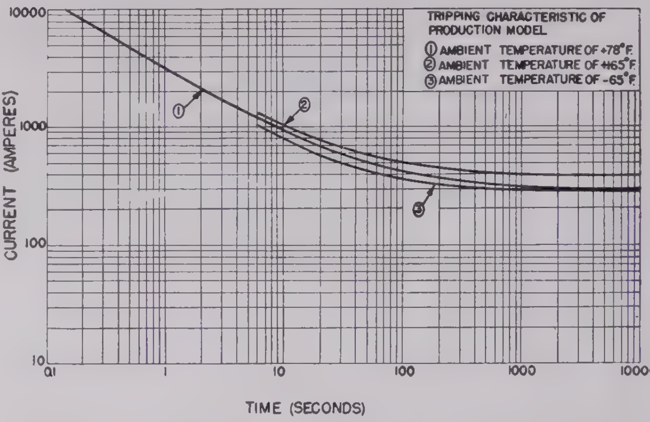

Figure 2. Tripping characteristics of production model

For operation at high altitudes and subzero weather the directional protector was built into an air-tight case. The air was purged from the case and an atmosphere of moisture-free nitrogen at three pounds per square inch substituted. To detect any possible leakage of moist air into the case, a considerable quantity of indicator-type silica gel is contained within an interior compartment and may be observed through a window.

To prevent excessive heat being generated in the protector during forward current operation, all current-carrying joints are silver-soldered and the contacts are made with a 2-inch radius dome surface. The forward continuous current allowable is 400 amperes with a forward current of 1,000 amperes permissible for short periods.

The protector safely interrupts reverse currents from 300 to 10,000 amperes at 6 to 30 volts d-c without damage to itself, and its operation is not affected by vibration.

The protector is being made on a production scale and is satisfactory for use on multiengine aircraft, with a 28-volt d-c system, for protection against sustained or high-current faults in generator circuits.

Digest of paper **49-201**, "Directional Current Circuit Protector," recommended by the AIEE Committee on Air Transportation and approved by the AIEE Technical Program Committee for presentation at the AIEE Pacific General Meeting, San Francisco, Calif., August 23–26, 1949. Not scheduled for publication in AIEE *Transactions*.

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A One Slip Cycle Out-of-Step Relay Equipment

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A new, quick-action relay, which will recognize an out-of-step condition in the first slip cycle and the relative direction of the slip, has been developed recently. Rapid correction of an out-of-step condition or removal of a machine from a system can be accomplished before a disturbance results in loss of load.

WHEN the out-of-step condition develops on a power system, the resulting disturbance may result in a major loss of load. It is, therefore, desirable to be able to recognize such a condition promptly and to take corrective measures to minimize the disturbance. This article describes a new relay equipment which is capable of recognizing an out-of-step condition before the completion of the first slip cycle, whereas earlier forms of out-of-step relays did not usually give an indication until after the third slip cycle.

Such a relay may be used in a number of different ways:

1. The separation of a system into two or more sections at preselected points so that each section may have sufficient generation to meet its own load requirement.[1]
2. To disconnect a machine which is out-of-step from the system in order to avoid damage to the machine.[2,3]
3. To correct an out-of-step condition in the case of a generator by controlling the input to the prime mover so as to either slow down or speed up the particular machine.[4]

This new relay equipment, in addition to recognizing an out-of-step condition more quickly than previous relays, has the further feature that it is capable of determining the relative direction of slip, thus permitting application for case 3 above.

One previous type of out-of-step relay uses three reversals of power as an indication of an out-of-step condition. An overcurrent relay is used as a fault detector so that it is necessary to have higher than normal current and also a power reversal before the reversal is counted. When a fault occurs the current is high and the power may reverse. Then while the fault is still on, one circuit breaker may open and change the conditions so that the power reverses again. Since it is possible to have two power reversals accompanied by high current during a fault, it is necessary to block the relay from operating on the first two power reversals. As there is only one power reversal accompanied by high current each slip cycle, this relay cannot trip on out-of-step until the third slip cycle.

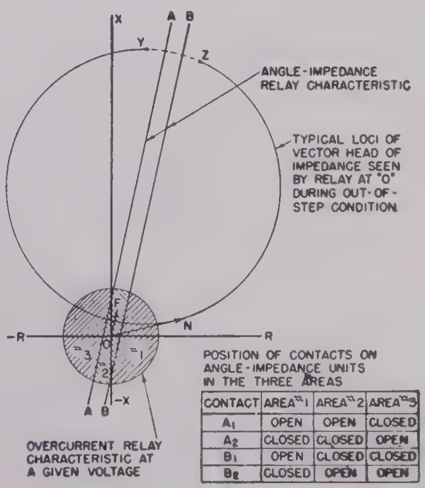
Other previous out-of-step relays use voltage dips or current surges to indicate the out-of-step condition. These types of out-of-step relays also have to be blocked for the first two voltage dips or current surges to prevent them from tripping incorrectly during faults not involving an out-of-step condition.

A new relay scheme that will trip correctly for an out-of-step condition during the first slip cycle and will not trip incorrectly during a fault is based on establishing three areas as shown in Figure 1. During an out-of-step condition the impedance seen by the relays located at *O* will always pass through each of the three areas in sequence and will be in each area for a time determined by the rate of slip. The out-of-step condition is recognized by the relay equipment through a chain of auxiliary relays which must be picked up in proper sequence and with a certain minimum time required for each step.

By establishing the three areas it is possible for this relay scheme to determine the relative direction of slip. If the slip is in one direction the impedance vector will go through area number 1, then area number 2, and finally area number 3. If the slip is in the opposite direction it will go through the areas in the sequence, area number 3, area number 2, and then area number 1. How these two sequences can be used to set up different circuits is described later.

The relay equipment is composed of two relays. One relay, known as the angle impedance relay, Figure 3, is composed of two induction cup units, one with characteristic *AA*, Figure 1, and the other with characteristic *BB*.

These units are similar to standard reactance units, differing only in that their characteristics have been shifted so they are parallel to the system impedance. These same


X
A
B
Y
Z
ANGLE-IMPEDANCE RELAY CHARACTERISTIC
TYPICAL LOCI OF VECTOR HEAD OF IMPEDANCE SEEN BY RELAY AT "O" DURING OUT-OF-STEP CONDITION
F
N
-R
R
O
#3
#2
#1
-X
A
B
OVERCURRENT RELAY CHARACTERISTIC AT A GIVEN VOLTAGE

POSITION OF CONTACTS ON ANGLE-IMPEDANCE UNITS IN THE THREE AREAS

CONTACT	AREA #1	AREA #2	AREA #3
A_1	OPEN	OPEN	CLOSED
A_2	CLOSED	CLOSED	OPEN
B_1	OPEN	CLOSED	CLOSED
B_2	CLOSED	OPEN	OPEN

Figure 1. Impedance characteristic of out-of-step relay scheme

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Full text of paper **49-261**, "A One Slip Cycle Out-of-Step Relay Equipment," recommended by the AIEE Committee on Relays and approved by the AIEE Technical Program Committee for presentation at the AIEE Fall General Meeting, Cincinnati, Ohio, October 17–21, 1949. Scheduled for publication in AIEE *Transactions*, volume 68, 1949.

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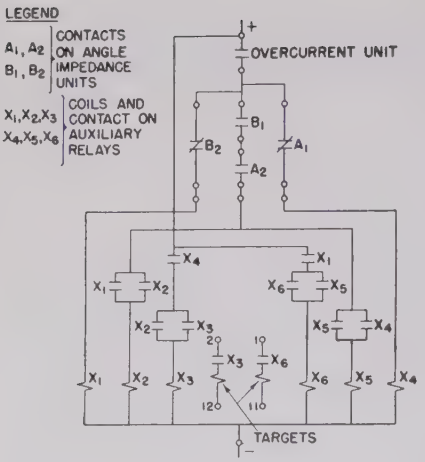

Figure 2. Control circuit of out-of-step relay scheme

units have been used as blinders for long line applications.[5]

Each unit has two contacts. The *A* unit has a contact A_1 which is closed for all impedances to the left of characteristic *AA* and a contact A_2 that is closed for all impedances to the right of characteristic *AA*. The *B* unit has a contact B_1 which is closed for all impedances to the left of characteristic *BB* and a contact B_2 that is closed for all impedances to the right of characteristic *BB*.

The other relay, known as the "overcurrent and time-delay relay," is composed of one plunger-type overcurrent unit and six telephone-type time-delay auxiliary relays. The overcurrent relay characteristic is shown as a circle in Figure 1, although it is really a family of circles depending on the voltage, due to the fact that it has a fixed pickup in amperes.

The telephone-type auxiliary relays are used to set up the trip circuit or control circuits when they are picked up in the proper sequence.

HOW THE TWO RELAYS OPERATE

The contact circuits of the two angle impedance units and the contact and coil circuit of the overcurrent and telephone-type relays are shown in Figure 2. Contacts on the angle impedance units which are closed in each area are shown in Figure 1.

Under normal conditions the impedance seen by the angle impedance units at location *O* will be to the right of characteristic *BB* but outside the overcurrent relay characteristic. When an out-of-step condition appears the impedance vector will move to the left. When it crosses into area number 1, the overcurrent unit will close its contacts. As contact B_2 is closed in this area the telephone-type relay X_1 will be energized and will pick up provided contact B_2 stays closed for 0.005 second after the contacts of the overcurrent unit close. When the impedance vector crosses into area number 2, contact B_2 will open and de-energize coil X_1 and contact B_1 will close. As contact A_2 is closed in area number 2 the coil of X_2 will be energized, provided X_1 has had time to pick up while the vector was crossing area number 1. When X_2 picks up it seals in around the contact of X_1 in its coil circuit.

When the impedance vector crosses into area number 3, contact A_2 opens and de-energizes X_2 and contact A_1 closes and energizes X_4. The contacts of X_4 energize X_3 provided X_2 had time to pick up while the impedance vector was crossing area number 2. When X_3 picks up it closes its contacts (studs 2-12) and also seals in around the contacts of X_2. When the impedance vector passes out of area number 3 by crossing the overcurrent units characteristic, the contacts of the overcurrent unit will open and de-energize X_3.

However X_3 has an adjustable time delay drop-out from 0.5 to 3 seconds. Therefore, if the time of one slip cycle is less than the drop-out time setting of X_3, then X_3 will be re-energized before it can drop out and will remain picked up. If the time of one slip cycle is more than the drop-out time setting of X_3, then X_3 will drop out after the time delay has expired, but will be picked up again on the next slip cycle. The foregoing cycle was based on one part of the system having fallen behind the other. If this same part of the system starts to go out-of-step by pulling ahead of the other, the impedance vector will go through the three areas in the sequence of area number 3, area number 2, and finally area number 1. This reversed sequence will cause relays X_4, X_5, X_1, and X_6 to operate and the contacts of X_6 (studs 1 and 11) will close.

When a fault occurs the impedance vector changes instantly from some value to the right of characteristic *BB* and outside the overcurrent characteristic, such as *ON*, to a new value in area number 2 such as *OF*. As this change is made instantly neither auxiliary X_1 nor X_4 have a chance to pick up before the contacts of A_1 and B_2 are both open.

The purpose of the overcurrent unit is to prevent opera-

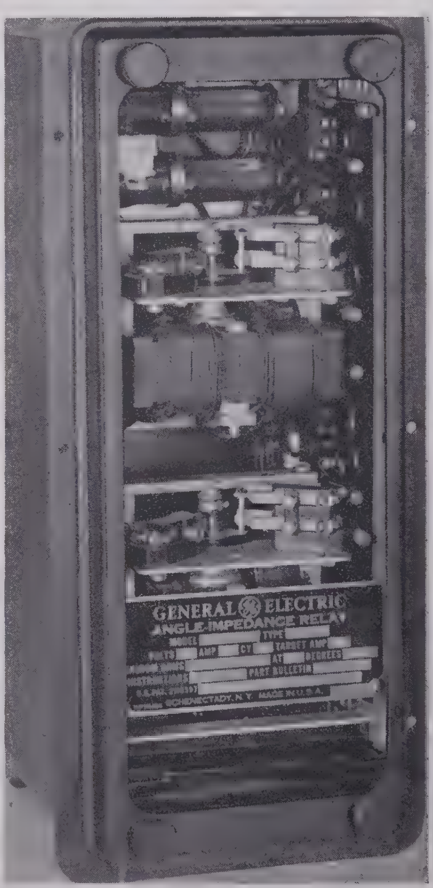

Figure 3. Angle-impedance relay

tion on normal oscillations such as caused by the generator hunting. The loci of the vector heads will oscillate back and forth along some line such as *YZ*, Figure 1. Even though the impedance vector crosses the *AA* and *BB* characteristics in the proper sequence, it cannot cause the auxiliary relays to set up the trip or control circuits because this is blocked by the contacts of the overcurrent unit remaining open.

The distance between the two impedance angle relay characteristics *BB* and *AA* determines the maximum slip cycles per second at which the relay scheme will operate. The maximum slip cycles per second is determined by the pick-up time of the time delay relays. These relays will pick up in approximately 0.005 second. If the impedance vector crosses between *BB* and *AA* in less than 0.005 second, the auxiliary relays will not pick up and the relay scheme will not operate. The time required for the impedance vector to cross between the *BB* and *AA* characteristic is related to the number of slip cycles per second and the number of electrical degrees between the characteristic by the following equation:

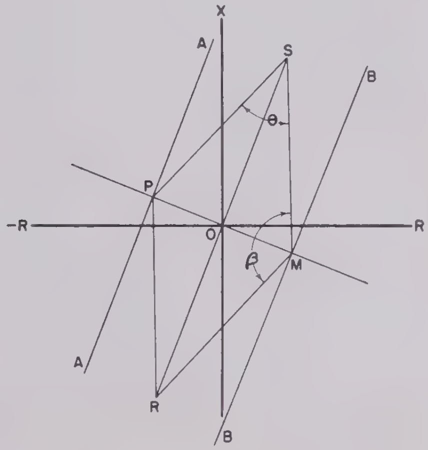

Figure 4. Relation of angle-impedance relay characteristics to impedance seen by relay

$$t=\frac{1}{S}\times\frac{\theta}{360} \qquad (1)$$

where *S* is the number of slip cycles per second, and θ is the change in the angle of the impedance vector, as seen by the relay, as the vector crosses between the two characteristics.

By substituting the pick-up time of the time delay relays (0.005) in this equation, the maximum slip cycles ($S_{\max}$) can be found.

Thus

$$S_{\max}=\frac{\theta}{1.8} \text{ cycles per second} \qquad (2)$$

It is necessary to change θ from electrical degrees to relay ohms in order to set the relay. In Figure 4, line *R-S* is the impedance of the total circuit and point *O* is the electrical center. β is the angle between the two ends of the system.

The ohm setting of the *B* angle impedance unit is *OM* and ohm setting of the *A* angle impedance unit is *OP*. As both units are set the same $OM=OP$, and $OR=OM\times$ $\tan \beta/2$. From this equation and equations 1 and 2 it is possible to obtain the curve shown in Figure 5. This shows the maximum slip cycles per second at which the relay scheme will work. By knowing the total ohms of the system and the maximum slip cycles at which the relay must operate, it is possible to determine the relay setting. The relay is adjustable from 0.25 to 2.5 ohms phase-to-neutral in one per cent steps.

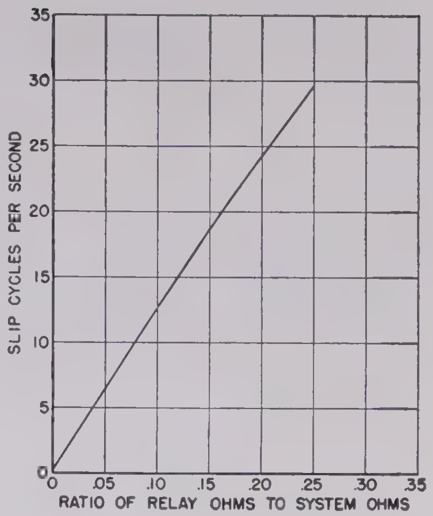

Figure 5. Curve showing maximum slip cycles at which relay will operate relative to relay setting

LIMITATIONS

When a generator loses excitation it will lose synchronism, but the impedance values as seen by a relay at the generator terminals do not follow the typical loci of Figure 1. Hence, this out-of-step relay may not operate in the case of loss-of-excitation. To protect the generator against out-of-step due to loss-of-excitation it is necessary to use a different relay known as a loss-of-excitation relay.[6]

This relay scheme will not operate while a fault is on the phases associated with the relay because the impedance vector crosses only one of the two relay characteristics. However, this relay will operate on the first slip cycle after the fault is cleared.

CONCLUSIONS

A relay scheme now is available that will correctly detect an out-of-step condition during the first slip cycle. It also will indicate whether one part of a system is running ahead or behind the rest of the system, and different control circuits can be used for the two conditions if it is desirable for any particular application.

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Deionization Time of Fault-Arc Paths

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AUTOMATIC RECLOSING of circuit breakers in high-voltage transmission lines can increase system transient stability limits provided reclosure can be accomplished rapidly. Minimum time of reclosure is dependent largely on the rate of dielectric recovery of the ionized fault-arc path. Data on deionization times of fault-arc paths have been obtained from tests on a 115-kv system.

The deionization times were obtained by continuously measuring the arc-path resistance during the recovery period. The method used was to apply a voltage across the ionized path and to record oscillographically this voltage and the current it produced through the path. This potential was supplied from a source whose voltage and impedance were such as to limit the current through the arc path to a maximum of 70 milliamperes after fault current had been interrupted, and to restore normal operating voltage across the arc path as soon as its conductivity had essentially disappeared. As the arc path deionized, its resistance increased; consequently, the current from the high-impedance source decreased causing the potential applied across the arc path to rise. Complete interruption of current flow permitted the measuring potential to rise to 66 kv (normal line-to-ground voltage).

Data on deionization times were obtained for single-phase faults on a 115-kv grounded-neutral system. Fault currents varied from approximately 3,000 to 16,000 amperes rms, and fault duration varied from 0.75 to 10 cycles. These data show that, within the limits covered by the tests, the magnitude of fault current is not a major factor in determining deionization time. The rate of dielectric recovery of the arc path appears to be determined by fault current duration. Recovery time was taken arbitrarily as the interval from fault-current interruption until the path resistance at high voltage reached 250,000 ohms. In some cases recovery was characterized by several sudden decreases in path resistance. In these cases recovery time was measured from fault interruption until the recovery interruptions had ceased.

Results obtained are probably conservative as to reclosing time because an effective path resistance of 250,000 ohms is probably more than ample. Reclosure into a path resistance of 50,000 ohms would probably be successful. The significance of the recovery interruptions has not been determined. These reductions of path resistance are probably the result of eddying of the masses of ionized gas; whether reclosure must be delayed until this phenomenon has ceased has yet to be determined.

Ultrarapid motion pictures (3,000 frames per second) were taken of several of the arcs. The pictures explain why long-duration faults result in slow dielectric recovery of the arc path. Short-duration faults produced a small diameter vertical column of luminous gas which broke into segments and rapidly disappeared after fault current interruption. In the cases of long fault duration, even at relatively low currents, very large volumes of luminous gases were created which cooled and broke up slowly; furthermore, magnetic forces caused the arc to progress along the fault busses ionizing gases over a considerable area. The hot gases produced along the lower fault bus rose toward the upper bus as a large billowing mass prolonging conduction between busses.

In order that definite reclosing times may be established, more data are needed. Further tests on the Bonneville Power Administration 115- and 230-kv systems are planned; moreover, it is proposed that manufacturers having suitable facilities incorporate such tests as a part of routine and special high-voltage circuit-breaker tests. In addition, a series of reclosing tests should be performed in an attempt to establish what high-voltage arc-path resistance is necessary to permit successful reclosure, and to determine whether the recovery interruptions of arc path previously discussed are of such a nature as to permit re-ignition if reclosure is made during that period. It is believed that these investigations should be organized to provide more data similar to that presented here.

The following conclusions were reached as a result of these tests:

1. A method of obtaining useful data on fault-arc deionization time has been devised. It is hoped this will lead to obtaining additional data which, when summarized, will enable minimum reclosing times for 115- and 230-kv circuits to be established.
2. Deionization time of arc path is principally a function of fault duration.
3. On the 115-kv system, variation of fault magnitude (three-phase equivalent) from 750 to 1,700 megavolt-amperes had very little influence on maximum deionization times of the arc path. For fault magnitudes of 2,000 to 3,000 megavolt-amperes, maximum deionization times were increased somewhat.
4. Although data contained herein are not conclusive, the indication is that for fault clearing times of four cycles, 3-phase reclosure may be feasible after ten cycles of dead time. Reduction of fault duration to three cycles indicates only seven cycles of dead time; while two cycles of fault duration indicate approximately five cycles of dead time prior to reclosure on a 115-kv system. This serves to illustrate the importance of high-speed relaying and fast circuit breakers on systems contemplating ultrafast reclosing.
5. While decrease in fault clearing time is always desirable and future developments may make this possible, it may not be feasible to decrease reclosing time below a certain limit as determined by multiple-lightning-stroke phenomena.
6. The presence of insulator strings in the arc path does not appreciably decrease deionization time. The use of small diameter copper wire for fault initiation does not appreciably delay deionization of the arc path.

Digest of paper **49-205**, "Deionization Time of High-Voltage Fault-Arc Paths," recommended by the AIEE Committees on Instruments and Measurements and Transmission and Distribution and approved by the AIEE Technical Program Committee for presentation at the AIEE Pacific General Meeting, San Francisco, Calif., August 23–26, 1949. Scheduled for publication in AIEE *Transactions*, volume 68, 1949.

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Latin America and the Young Engineer

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Although it will be of greatest value to young engineering graduates and seniors who are thinking of entering foreign service, this article contains much of interest to the general reader who wants to know more about living conditions and employment opportunities in Latin America.

IN HIS Inaugural Address in January 1949, President Truman declared that the United States, in co-operation with the United Nations and with other governments, should attempt to pool the technical knowledge and skills of the more advanced countries to stimulate the progress of the underdeveloped countries. Conceived as a "bold new program" to provide "triumphant action...against the hunger, misery and despair" for the world's free people, it has been very widely commented upon and discussed as the "Point Four" program.

In a recent address, Spruille Braden, former American Ambassador to Argentina, endorsing President Truman's proposal to aid underdeveloped areas, said that there was no area where the "Point Four" program could be "assayed under more propitious circumstances" than in Latin America. Engineering will definitely play a very prominent part in such a program, and if, as suggested by Mr. Braden, it is tried out first in Latin America on an experimental basis, then the opportunities in that area for North American engineers, and particularly for young engineers, will be greatly expanded.

The young engineer in considering a career in Latin America will naturally have many questions in mind and will want to weigh very carefully the advantages and disadvantages of employment in a foreign country as compared to those in the United States or Canada. He also will want to know something about the preparation that will best fit him for success in this field, and about the opportunities for growth and development that work in Latin America offers. The purpose of this article is to answer as many as possible of the questions that usually are asked, and to point out the pitfalls of inadequate educational or mental preparation for what generally proves to be a radical change in one's manner of living and entire outlook on life.

GEOGRAPHIC CHARACTERISTICS

To generalize about Latin America is simply not possible. The 20 Republics of Middle and South America present extreme variety in size, population, racial origin, language, and climate.

The ten Republics of Middle America are, with the exception of Mexico, relatively small, varying in size from Haiti, which has about twice the area of Connecticut, to Nicaragua with an area almost exactly the same as that of New York State. The ten Republics of South America, on the other hand, range in size from Uruguay, slightly larger than the State of Washington, to Brazil with almost 3,300,000 square miles, an area almost equal to that of the entire United States.

The combined population of the 20 Republics, based largely on estimates, is 150,000,000, and therefore about equal to that of the United States as a whole. Nearly one-third of Latin America's population, or some 47,500,000 people, live in one country—Brazil. Mexico is next in line with an estimated 22,500,000 people, tapering down to Costa Rica and Panama, which have a population of only 600,000 to 700,000 each. Population density also varies between wide limits; Bolivia has eight persons per square mile, while Haiti has 255, and some of the islands in the West Indies run up to 1,000 per square mile.

Indian blood predominates in two widely separated regions: Mexico and Guatemala with their Aztec inheritance; and Peru, Ecuador, and Bolivia with their Incaic background. Today, two-thirds of the population of Guatemala is still pure Indian. By contrast, in Uruguay there is scarcely a trace of Indian blood. Haiti is practically 100 per cent negroid, while in Argentina the negroid and Indian population is less than one per cent.

Spanish is generally considered the language of Latin America, when, as a matter of fact, the one-third of the population of Latin America living in Brazil speaks Portuguese, while some three million persons in Haiti use the French tongue.

Since by far the greater part of Latin American is situated in the tropical zone, it is generally considered "hot country." Actually, climatic conditions vary between rather wide limits. Northern Mexico, southern Brazil, most of Argentina, and much of Chile are in the temperate zones, but the factor affecting climate most strikingly is altitude. Quito, Ecuador, located practically on the Equator, has a delightful climate due to its elevation of some 9,000 feet above sea level. Other cities enjoying climatic advantages because of altitude are the city of Mexico, Mexico; Caracas, Venezuela; Bogotá, Colombia; and La Paz, Bolivia.

Still another factor profoundly affecting the climate is the Humboldt or Antarctic Current which washes up the West Coast of South America, making a coastal city like Lima, Peru, a very pleasant place to live.

Another interesting variation is found in the food habits of the people. In Mexico and Central America corn is the staple food of the poorer classes, and is usually eaten in the

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form of "tortillas." Throughout the West Indies rice is the principal dietary base, while in the Andes of Peru and Bolivia, the original home of the potato, the potato is still king.

From this brief survey of the wide variety of conditions that will be encountered in Latin America, it should be apparent that anyone embarking on engineering work in one of the 20 Republics will want to learn in advance just as much as he possibly can about conditions in the particular locality in which he will live.

HEALTH CONDITIONS, EDUCATIONAL FACILITIES, AND CLOTHING

Health conditions are naturally a first consideration, especially where a wife and family are involved. Fortunately, in the last few decades there has been a marked improvement in health conditions throughout most of Latin America, and with reasonable care one can live just as well, and in some instances better, than in the United States. There is more opportunity for a healthful outdoor life the year round. Children's diseases are usually milder than in the North, and while enteric disturbances are more prevalent, respiratory infections are relatively rare among people who are well fed and well housed. With reasonable care and simple prophylactic measures, there need be no undue concern about drinking water and food. In the more tropical sectors one soon learns to avoid water that has not been boiled or treated. Uncooked vegetables of any kind usually are avoided, also. In the larger centers hospitals and medical care are of a high order.

Educational facilities have shown very great improvement and have become more widespread, particularly in the last ten years. So-called "American schools" are to be found in most of the large cities, and where sizable American firms operate they almost invariably provide elementary schools and teachers from the United States for the children of their staff. Children educated in these schools usually become bilingual, an asset of considerable value. While they are often sent "North" for their high school or college education, they gain in adaptability much more than they may lose from the lack of continuity in their school work.

Clothing requirements will vary with climatic conditions, and with location in the field or large population centers. In the altitudes, woolen clothing is a necessity, while in the tropical areas, lightweight washable clothes are called for. Information can usually be obtained on the type of clothing used in the locality to which one is going, and it is almost always wise to take along sufficient clothing, and especially shoes, necessary to last until the next expected visit to the United States. In many situations formal evening clothes are more essential than in the North.

OPPORTUNITIES AND EDUCATIONAL REQUIREMENTS

Engineering work in Latin America usually offers an opportunity for broader experience in a shorter time than is possible at home. Advancement is likely to be more rapid, and the compensation somewhat better, offering an opportunity to accumulate a nest egg. While it is true that it becomes somewhat difficult after a few years to switch to similar work in the North, largely because a man has become more valuable to an organization in the South, it is a fact that most firms follow the policy of bringing seasoned men in from the field to direct their foreign operations from the home office.

But one goes abroad not only to work, but also to live. Living in Latin America, or in any foreign country, calls for adjustments and great powers of adaptability. Young people, as a rule, adapt themselves to new situations and living habits and customs much more readily than do older people. This is borne out by the experience of a number of engineering organizations, who have found that the best time to start the engineer out in the foreign field is within a few years of graduation from his engineering course, and preferably about the time he has just been married. Only in rare instances have older engineers and their families adapted themselves successfully to conditions to which they were not at all accustomed.

Going abroad not only to work, but also to live, one should enjoy to the fullest extent possible the opportunities that foreign residence offers. Those who make friends among the local people and enter the social and cultural life of the community in which they live find themselves richly rewarded.

Technical competence is essential, particularly in isolated situations where the engineer must be self-reliant; but many other qualifications are necessary for success. Most important, perhaps, is a liking for people and the ability to get along with them. Next, perhaps, are tolerance and patience. The ability to teach and train others is almost invaluable.

A well-rounded education, supplemented by reading in the history, geography, economics, and social conditions of the countries in which one is working, will contribute measurably to one's understanding of the problems to be faced and to success in handling them. Sound basic training in the grammar of the language of the country—Portuguese for Brazil, and Spanish for the other countries, except Haiti—is a prime essential. Though preferably acquired before foreign residence, it can be acquired in the country of residence under competent local teachers. Speaking facility is usually best attained by practical everyday use of the language while at work and through social and business contacts.

The wife of the engineer in foreign work contributes much more to his success or failure than she would at home. Her problems of adaptation are often more difficult than those of her husband. She will have more domestic help than she would in the North, but the problems of homemaking and raising a family in unfamiliar surroundings will not be easy. If, however, she is resourceful and can make the necessary adjustments, she will be amply repaid in the enriching experience of foreign residence, and the success that she will help her husband achieve in his professional work.

If she has had any experience in business or in teaching, these may prove very useful. A frequent cause of unhappiness among wives of men in foreign work is the lack of something with which to keep themselves occupied. If there is no family there is usually an opportunity for gainful and constructive employment with consequent greater contentment.

Unless one is prepared to go into foreign work as a career, rather than exile, he should not undertake it. Unless one desires to learn everything he can about the people among whom he lives, their habits, customs, culture, and history, and unless he is prepared to teach them the know-how that will help them to progress on their own, he had best remain at home.

The United States has a diplomatic staff in each of the Latin American countries. The fact remains, however, that some of the best emissaries to these countries are representatives of industrial and engineering organizations. A case in point, and an outstanding example of a man who has made a success of his engineering work, is the late Asa W. K. Billings, who a few years ago was awarded the highest nonmilitary decoration of Brazil—the National Order of the Southern Cross. More recently the Brazilian Traction Company, for whom he first went to Brazil many years ago as a construction engineer, named one of its largest dams in his honor—Billings Dam.

Omaha-born, Harvard-educated Billings, who was over 70 when he died recently, developed a philosophy that might well be passed on to those contemplating engineering work in Latin America: "An engineer has to have confidence in the country where he works. People who want to go back to God's country in a hurry don't make out so well."

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A 30,000/40,000-Kva Autotransformer

The transformer on the front cover, designed and manufactured by the Allis-Chalmers Manufacturing Company of Milwaukee, Wis., from specifications furnished by the Empire District Electric Company of Joplin, Mo., will be installed at Empire's Riverton, Kans., generating plant. It will transmit the entire output of the new 30,000-kw turbogenerator, which will be placed in service the first quarter of 1950. This turbogenerator has additional capacity when operated under increased pressure of hydrogen, and it was therefore necessary to obtain additional capacity in the autotransformer. This was obtained by forced-air cooling which is automatically controlled by hot-spot temperature equipment.

In this new transformer is a 13.2-kv delta tertiary winding with full name-plate capacity, and it is direct-connected to the generator through an oil circuit breaker. The generator and autotransformer will operate as a unit. Special bushings through the wall of the transformer provide for direct connection to an auxiliary 3-phase transformer which supplies power to all auxiliaries of the turbogenerator, thereby making the installation a self-contained unit. The autotransformer winding transforms from either 132 or 161 kv to 69 kv. The dual high-voltage rating is due to both of these voltages being used in the step-up station, and the bus arrangement is such that the transformer can be connected to either bus in a short time. Either the 132- or the 161-kv winding can be connected to the high-voltage bushing in the transformer by externally operated tap-changers. A 17-position load ratio control to vary the 132-kv winding, within plus or minus ten per cent, has been included.

The transformer has full capacity down to 125 kv. The load ratio equipment has remote control and indication as well as electric and manual controls at the transformer. Three wound-type double ratio current transformers are in the high-voltage leads with provisions on the high-voltage bushings for changing the ratio. Three low-voltage wound-type single-ratio current transformers are installed at the neutral end of the auto winding. These current transformers provide for ammeter readings in the common winding which permit an accurate method of determining the true load on the transformer.

A pressure relay has been installed to provide clearing of the transformer and the station bus in case excessive pressure is built up in the transformer as a result of an internal failure.

Fault Locator for High-Voltage Lines

L. R. SPAULDING ASSOCIATE AIEE
C. C. DIEMOND MEMBER AIEE

THE LOCATION of high-voltage power line faults has received considerable attention during the postwar years. Three systems of locating faults by echo-ranging means have been covered in previous papers.[1,2]

This article describes the Bonneville Power Administration's type-*C* fault locator which utilizes a pulse-radar method of echo-ranging for fault location. This system is designed for use where wide-band communication circuits are not available. It provides a freedom from spurious pulses which are associated with the surge immediately after the fault and an easily interpreted record when photographic recording is used. A direct reading record from an electronic counter is possible. No interference is caused to closely associated communication facilities.

Improved methods of coupling the equipment to the faulted line through coupling capacitors were developed. A single applied unidirectional pulse was selected.

During the waiting period between faults, the locator is not connected to the line. On occurrence of a fault in the line section, a simple phase-selecting relay scheme connects the fault locator through one or more carrier coupling capacitors to the faulted line and ground. At about 33 milliseconds from the start of the fault, a one microsecond d-c pulse from a 10-kv source is applied to the line after which the pulsing unit is disconnected and a receiving unit is actuated. A measure of distance is provided by the time required for this pulse to travel to the fault and return to the receiving equipment.

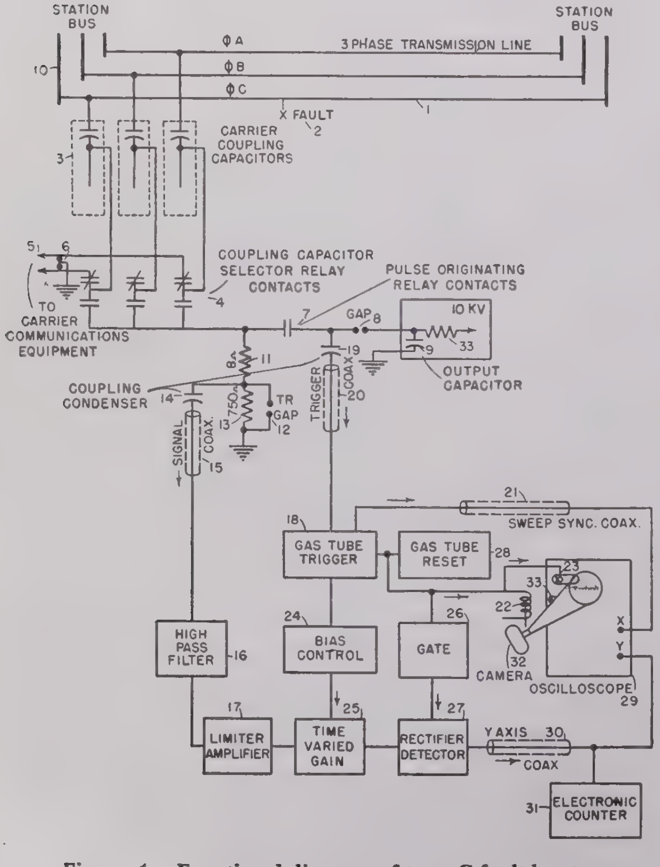

Figure 1. Functional diagram of type-C fault locator

The principal components in addition to the phase-selecting relay system include carrier-current coupling capacitors, a 10-kv pulse generator, an oscilloscope and camera (or an electronic time counter), a high-pass filter limiter amplifier, time-varied gain and bias control, a trigger circuit, and a rectifier detector. In the experimental model, the oscilloscope and camera are used to check the operation of the electronic counter as well as to provide permanent data and records on transmission line surges.

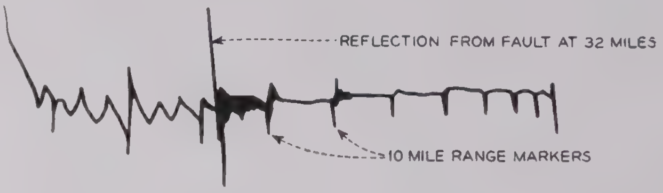

Figure 2. Tracing of oscillogram for single phase-to-ground arcing fault at 32 miles

In operation, the initial pulse will start the electronic counter which records the number of one-microsecond time intervals until it is stopped by a reflected pulse from the fault. The time necessary for the pulse to travel one mile and to be reflected back to the point of origin is 10.73 microseconds.

Investigation of this system included a number of tests using an unenergized 230-kv line and permanent fault connections of various types on the line. A limited number of actual faults using the same line while it was energized also were applied in order to check the previous experiments.

These tests showed that the most pronounced reflections are obtained from a fault when one of the faulted phases is pulsed. A good reflection was also obtained when the two unfaulted phases were pulsed in parallel for a fault on the third phase. This latter method is used for faults involving the phase being used for carrier relaying service.

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Digest of paper **49-206**, "A Transient Fault Locator for High-Voltage Transmission Lines," recommended by the AIEE Committees on Instruments and Measurements and Transmission and Distribution and approved by the AIEE Technical Program Committee for presentation at the AIEE Pacific General Meeting, San Francisco, Calif., August 23–26, 1949. Scheduled for publication in AIEE *Transactions*, volume 68, 1949.

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Modern Carrier Current Test Equipment

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DURING the past 20 years the carrier system of the Pacific Gas and Electric Company has advanced from two simple carrier circuits serving a total of seven terminals to the present system consisting of some 45 circuits and nearly 100 terminals. The system includes relay carriers, telemetering, and remote alarm systems. Some installations employ simple amplitude modulation, other installations transmit only one side band, while others employ frequency modulation.

Several test instruments have been developed to meet the needs of the carrier system of the Pacific Gas and Electric Company, and most of these are finding wide acceptance and usage among other power utilities and the communication companies as well. An oscillator capable of delivering five watts in the frequency range from 20 cycles per second to 200 kc per second has been invaluable. This instrument referred to as the carrier frequency oscillator provides both a balanced and unbalanced output with provisions for matching impedances of 50, 200, 500, and 5,000 ohms. The instrument also contains a modulator for modulation of the oscillator from an external source. An output level indicator consisting of a vacuum-tube voltmeter connected across the 500-ohm output winding of the matching transformer is included in the design.

For measurement purposes, a carrier-frequency voltmeter (designated Model *101*) has been designed and manufactured to measure voltages at any selected frequency in the range from 20 kc to 500 kc. The instrument is actually a radio receiver with the d-c output from the final detector operating an indicating meter on the front panel, calibrated to show the values of the voltages applied to the input terminals. The voltmeter operates with a fixed gain and is therefore a voltage measuring device at the frequency to which it is tuned. A telephone jack is provided on the front panel for use of a headset to listen to incoming signals. An injection oscillator, tuned to 100 kc, is included in the voltmeter to provide a fixed known amplitude signal of 0.77 volt rms for calibration purposes.

The voltage measuring range of the voltmeter is from 77 microvolts to 77 volts or 80 decibels below to 40 decibels above zero level. The calibrations indicate in decibels the ratios of voltages at the input terminals to the receiver.

A second model carrier-frequency voltmeter (designated Model *103*) has been manufactured to measure voltages at any frequency in the range from 3 kc to 40 kc. In other respects, this model is similar to the Model *101*, except that it has provision for reception of suppressed carrier transmission.

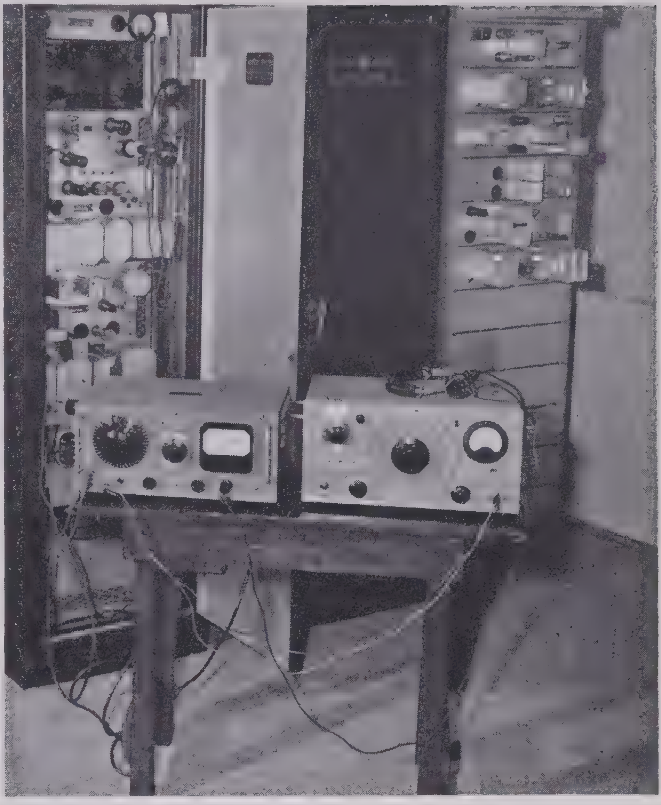

Figure 1. Carrier frequency voltmeter (left) and carrier frequency oscillator (right) connected for testing power line carrier current equipment

A third instrument frequently used in testing and maintenance, is an untuned vacuum-tube voltmeter with special built-in features. A set of terminals is added for connection to a cathode-ray oscilloscope. The signals are amplified in the vacuum-tube voltmeter circuit, thus making it possible to view relatively weak signals. A telephone jack is also included in the instrument for use of a standard headset to enable the user to make audible inspection.

The foregoing instruments, together with multitesters, tube testers, and so forth, make it possible for carrier maintenance personnel to maintain communication circuits and equipment in good working order and make routine performance checks so that incipient troubles can be located before actual failures occur.

In the application of the test equipment to correction of faulty carrier circuit operation, it is usual for the maintenance man first to examine the condition at the nearest circuit terminus. By connecting the carrier-frequency voltmeter across the circuit terminals, he is able to check the output level and modulation of both the local and remote transmitters. A similar use of the carrier-frequency oscillator connected across the terminals will indicate if the receivers are functioning properly.

Digest of paper **49-211,** "Modern Carrier Current Test Equipment and Its Application," recommended by the AIEE Committee on Carrier Current and approved by the AIEE Technical Program Committee for presentation at the AIEE Pacific General Meeting, San Francisco, Calif., August 23–26, 1949. Not scheduled for publication in AIEE *Transactions*.

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Heating of Transmission Line Clamps

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MAGNETIC HEATING of suspension and strain clamps has received increased design consideration because of higher transmission line currents. The temperature rise of conductors with sustained load currents of several hundred amperes may be excessive inside all-ferrous clamps. At these currents, a decrease in clamp magnetic power loss to reduce temperature rise may justify, economically, the purchase of more expensive nonmagnetic clamps.

An all-ferrous clamp which surrounds a conductor carrying alternating current has hysteresis and eddy current losses. Substitution of nonmagnetic material for certain parts of the clamp increases the reluctance to the magnetic force. The resulting decrease of flux in the magnetic loop decreases power loss and heating. Figure 1 shows the application of this method.

Three methods have been used to measure the magnetic power loss of clamps.

Current Transformer. High current is passed through a conductor by means of a current transformer. The power loss of a clamp is determined by subtracting the other circuit losses from the total input power. These other circuit losses are high compared to the small losses in nonferrous clamps; therefore, this method is not accurate when small clamp losses are measured.

Calorimeter. This method, in which the conductor and clamps are placed in an insulated water bath, is slow and inconvenient, and requires special equipment.

Multiturn Coil. The clamp is mounted on a multiturn coil of insulated wire instead of a single conductor. The loss is determined by subtracting the loss of the coil from the loss of the coil and clamp. This method was used in determining values presented in this article.

Figure 2 shows loss measurements of both all-ferrous and nonferrous-body suspension clamps. With increasing seat diameter there is a proportional increase in the length of the clamp and the volume of metal; hence power loss of the all-ferrous clamp increases. However, for the nonmagnetic body design the magnetic loss occurs primarily in the steel *U*-bolts and nuts. The flux path for *U*-bolts and nuts includes the air gap between the nuts. For larger clamps, this air gap is longer, and the reluctance is greater. Hence, the power loss of nonferrous-body suspension clamps decreases with increasing seat diameter. Measurements on one size of clamp may vary from the average by plus or minus ten per cent. These variations result from air gaps and nonmagnetic galvanizing between the ferrous parts.

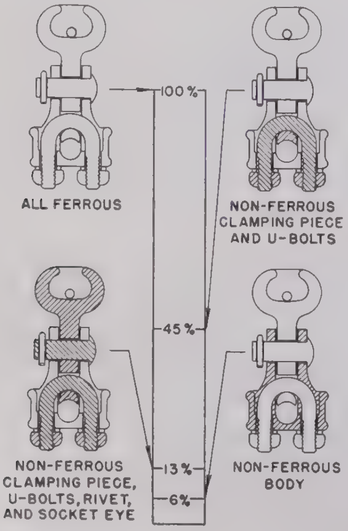
100%
ALL FERROUS
NON-FERROUS CLAMPING PIECE AND U-BOLTS
45%
NON-FERROUS CLAMPING PIECE, U-BOLTS, RIVET, AND SOCKET EYE
13%
6%
NON-FERROUS BODY

Figure 1. Power loss reduction with nonmagnetic parts

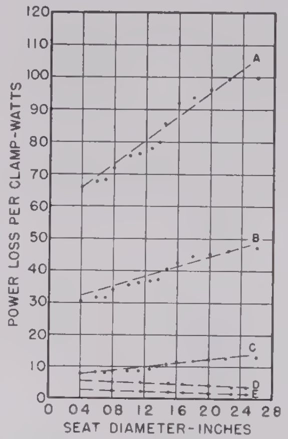

Figure 2. Power loss of suspension clamps versus seat diameter and conductor current

Ferrous—A, 600 amperes; B, 400 amperes; C, 200 amperes
Nonferrous—D, 600 amperes; E, 400 amperes

By reducing power loss of a clamp, nonmagnetic parts also reduce temperature rise above ambient of a conductor inside the clamp. The added heat-dissipating area afforded by a nonmagnetic clamp more than compensates for the small clamp power loss; therefore, the temperature of a conductor inside the clamp is less than that of the conductor in air. The converse is generally true for the all-ferrous clamps. From this the following conclusions can be drawn:

1. Several methods for measuring power loss in conductor clamps have been compared. The multiturn coil method is recommended for its simplicity and accuracy.

2. The reduction of magnetic loss in suspension and strain clamps is practicable. The use of a nonferrous body with all other parts iron and steel has proved to be an economical procedure.

3. Because of the magnetic loss characteristics of the clamps, a conductor inside all-ferrous suspension and strain clamps generally will be warmer than the conductor in air; a conductor inside nonferrous-body suspension and strain clamps will be cooler than the conductor in air.

4. A requirement that the clamp magnetic loss be less than ten watts per clamp at a conductor current of 400 amperes will assure a low power loss and a low temperature rise characteristic.

Digest of paper **49-212,** "Magnetic Heating of Transmission Line Clamps," recommended by the AIEE Committee on Transmission and Distribution and approved by the AIEE Technical Program Committee for presentation at the AIEE Pacific General Meeting, San Francisco, Calif., August 23–26, 1949. Scheduled for publication in *AIEE Transactions,* volume 68, 1949.

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Power Costs of Bituminous Coal Mines

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MEMBER AIEE

The use of electricity in coal mining has increased rapidly in the past 25 years. With wages increasing steadily it is economically wise for the mine owner to use more electric power and less man power. The total cost per unit of electric power to the mine owner is decreasing steadily. This decrease is brought about by improving the load factor of the mine and by the increased use of power which enables the owner to purchase more power in the lower-priced rate brackets.

THE TRENDS and amount of elecric power use and cost at bituminous coal mines are of interest to the executive, the operating man, and the engineer alike. A study of the data based on a single year, or even a few years, could result in misleading conclusions; but the data from over 400 representative mines for the past 26 years make it possible to determine the trends quite accurately. These trends, illustrated by graphs and tables, are discussed in this article.

HISTORY OF ELECTRICITY IN BITUMINOUS MINING

The use of electricity for mining coal began in a small way about 1879. Prior to that time, coal was hauled chiefly by mules or ponies, and at the face pick mining and compressed air punches were used to under-cut the coal seam. Coal-cutting machines of the Breast-type, first used in 1879, had increased in number to 545 by 1891, according to the first official United States Government record of the use of mining machines. Beginning about 1900 the Shortwall mining machine gradually came into general use, replacing the Breast machine.

During the two decades from 1880 to 1900, power plants at the coal mines furnished direct current chiefly for crude haulage locomotives, Breast cutting machines, and fan motors. In general, each mine had its own individual power plant. The mining operations were carried along as far as the relatively low-voltage direct current could be transmitted without excessive voltage losses. Mines using 550 to 600 volts could mine out large areas, but many of the mines, having adopted lower voltages for safety considerations, soon ran into trouble from their inadequate power supply. Many of the latter group gladly welcomed the advent of the central-station power companies, which, by means of a-c high-voltage transmission lines, were able to deliver electricity to converting or transforming substations conveniently located near the places where power was to be utilized.

Central-station sources of power supply came into prominence, particularly during the 6-year period of 1910 through 1915. Gradually these public utility central stations have taken over the furnishing of electricity for the operation of coal mines, until at the present time there are very few individual or private power plants in operation at mines located in the Appalachian bituminous coal mining areas (see Figure 1).

Records of power use and cost for mining coal were generally scanty and incomplete when private plants supplied the power requirements. In many instances no record was kept of the kilowatt-hours used, and only the powerhouse costs were known. On the other hand, as soon as the mines began to purchase electricity from the public utility companies, each month the amount of monthly kilowatt demand and energy requirements were recorded. Coal company managements became more cost conscious and more attention was directed toward the proper and efficient use of electricity for the production of coal. Nevertheless, each year the amount of electricity used for the mining of a ton of coal steadily increased. Wages have risen steadily over the years, while electricity became progressively cheaper, so it was natural and proper to mechanize the mining of coal and replace expensive labor with cheap electricity.

TRENDS IN POWER USE AND COST

This study of the use of electricity to be discussed in this article began in 1918 with a yearly analysis of power use and cost for a large group of mines having widely varying physical conditions and tonnage output. The scope of the analysis was enlarged, and more coal companies from many

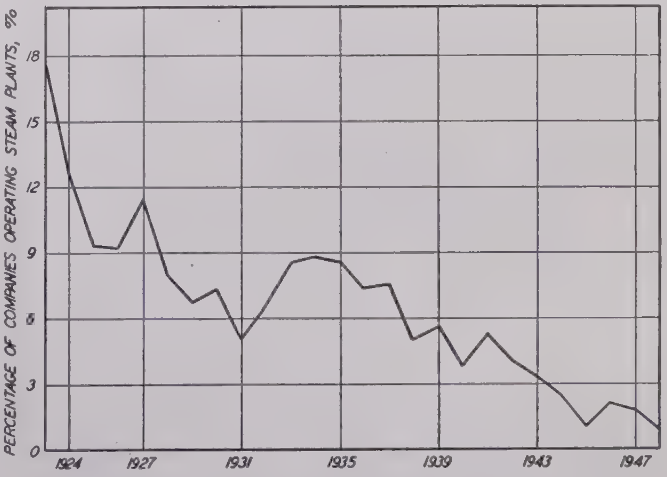

Figure 1. Companies operating their own steam plants

Essentially full text of a conference paper, "Analysis of Power Costs of Bituminous Coal Mines," presented at the AIEE Fall General Meeting, Cincinnati, Ohio, October 17–21, 1949.

H. P. Musser is President of the West Virginia Engineering Company, Charleston, W. Va.

Appalachian bituminous coal mining states were included in the study until by 1923 the items of data collected and the coal companies embraced had become stabilized and comparable data could be collected from practically the same group of mines.

For 31 years this analysis has been made; each year it covers over 400 mines, principally in West Virginia, Virginia, Kentucky, Tennessee, and Pennsylvania, with a few in Maryland and Ohio.

This article, based on these analyses, gives a comprehensive representation of the amounts and trends in power use and cost in bituminous coal mining during the last 26 years. The analyses cover mines using central-station power and mines employing individual private plants. The former are greatly in the majority. Typical of the dependence of the coal mining companies on central-station power for their supply of electricity and the disappearance of the individual private power plant from the scene, a curve has been drawn showing year by year the percentage of companies included in the annual analyses operating their individual power plants (Figure 1). In 1923 there were 18 per cent of the coal companies included in the analysis operating their own generating plants; while in 1948 this percentage had dwindled to 1.1 per cent. The opportunity of the central station to install and operate large, efficient steam and electric units enabled electricity to be delivered and sold at steadily decreasing costs, but the chief handicap suffered by the independent private plant has been the steady increase in labor costs over the years.

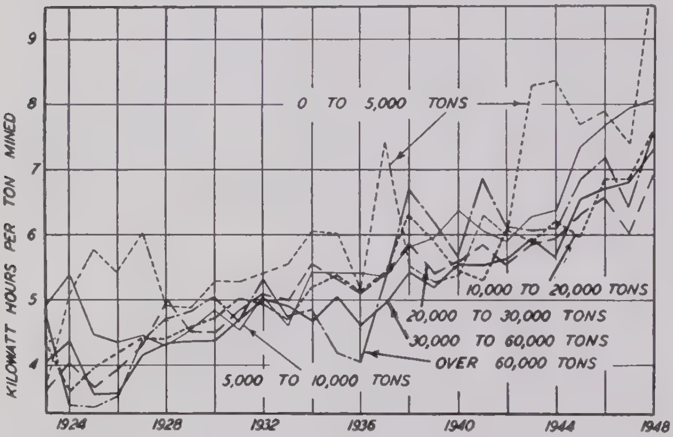

Figure 2. Electricity required to mine a ton of coal

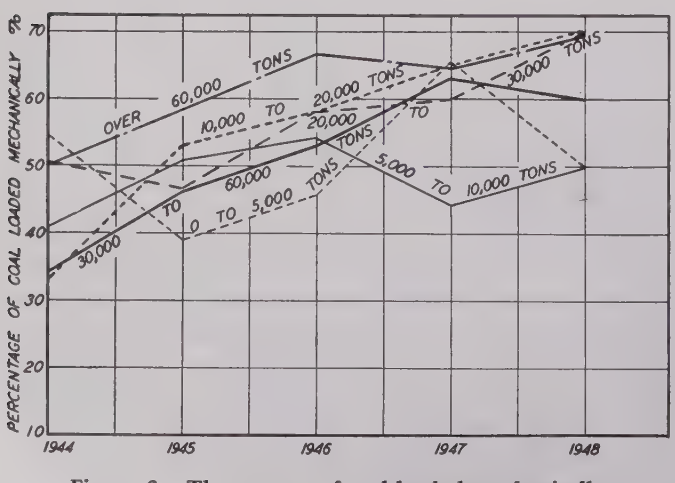

Figure 3. The amount of coal loaded mechanically

Because of the large variation in the comparable use of power between small tonnage output mines and large ones, the mines using central-station power have been divided into six monthly tonnage classes, ranging in output from the 0 to 5,000 tons per month class, to the very largest of over 60,000 tons per month. Mines of all tonnage classes using central-station power purchase it at the prevailing power rate in their locality. Usually the rates include a demand charge based on a definite time interval demand plus an energy charge with a block price scale. The data concerning power costs for these mines do not carry any fixed charges for any investment in electric equipment used at the mines, but the demand charges are usually considered as covering the fixed charges on the generating and distributing facilities that are required to supply the electric power.

Tabulations for mines having their own individual private plants have been recorded so as to be as nearly comparable as is practicable to those using central-station power. However, no fixed charges are included in the costs for the individual power plants for the reason that the methods of setting them up are extremely variable at the different mines. In some instances the entire powerhouse investments have been retired.

THE LONG-RANGE RECORD

A study of the record of the average mine in each class for each year from 1923 to 1948 shows the following facts.

Kilowatt-Hours Required Per Ton Mined. With each succeeding year more electricity is required for each ton of coal mined (see Figure 2). Electricity is cheap and its long-term cost trend is down. Therefore, it is sound management to harness electricity for every possible task, thus giving each workman a multitude of willing slaves. Whereas, coal was loaded into mine cars by hand for the first three decades of this century, the majority of coal mined now is loaded mechanically. Among the group of mines included in this study, the percentage of coal loaded mechanically has increased from about 40 per cent in 1944 to over 60 per cent in 1948 (Figure 3). It is cheaper to use electricity wherever it can be utilized efficiently than to use the muscles of either man or beast.

Cost of Units of Electricity. The total cost of a unit of electricity (kilowatt-hour) purchased by the mines, shows a steady and definite decreasing trend (Figure 4). This trend may be attributed in part to rate reductions, in part to bettering the load factor at which the electricity is purchased, but a large portion of it has been due to the increasing use of kilowatt-hours in the lower-priced brackets of the energy scale. The 1948 trend of unit cost was up because of inflationary prices of coal used for power generation. This increased cost of coal, acting through coal clauses in power rates, caused a temporary or intermediate upward trend in unit cost of electricity, but the long-term trend is toward lower unit cost.

It is interesting to observe the extent to which central stations can generate a kilowatt-hour with less coal and reduce the unit charge for electricity, while simultaneously the coal mines use more kilowatt-hours per ton of coal mined. The net result is that the cost of power for mining a ton of coal has remained almost constant for over 25 years. In order to show the long-term trends in this respect, Table I has been prepared taking a representative group of mines—those producing 10,000 to 20,000 tons of coal per month—and following the changes in power use and cost over a period of 29 years.

Table I. Changes in Power Use and Cost

	Generation of Electricity	Coal Mining Performance*		
Year	Coal Per Kilowatt-Hour, Pounds	Cost Per Kilowatt-Hour, Cents	Power Per Ton, Kilowatt-hours	Cost Per Ton, Cents
1920	3.39	2.180	4.40	9.59
1925	2.10	2.170	3.96	8.61
1930	1.62	2.000	4.73	9.48
1935	1.46	1.830	5.41	9.88
1940	1.35	1.709	5.48	9.37
1942	1.32	1.535	6.13	9.42
1947	1.31	1.532	6.85	10.49
1948	1.30	1.595	7.54	12.03

* Averages for a group of mines in the 10,000- to 20,000-ton class.

Column 2. Source, Federal Power Commission data covering all plants contributing to public supply and Edison Electric Institute for years 1947 and 1948.

Columns 3, 4, and 5. Source, West Virginia Engineering Company, "Analyses of Power Costs for Coal Mines." Figures shown are for a large group of mines (average 45) in the 10,000- to 20,000-tons-per-month class. This group shows typical average performance because it is midway between the smallest and largest mines, and the mines in this group usually show efficient performance.

By referring to Table I and considering the period of 24 years from 1925 to 1948, it will be noted that the average cost of a kilowatt-hour as purchased by this group of mines dropped 26.5 per cent, or on the average slightly more than 1 per cent per year. The amount of kilowatt-hours required to mine a ton of coal increased 90.4 per cent, or on the average the yearly increase was approximately 0.15 kilowatt-hours. Stated another way, the amount of power used to mine a ton of coal increased one kilowatt-hour during each 6.7 years. The increase was due to progressive mechanization, the growth in the size of the mines requiring more ventilation, pumping, longer haulage distances, and more preparation at cleaning plants. There was practically no increase in the cost of power used per ton of coal mined for this group of mines from 1925 to 1942—a period of 18 years—but the inflation during and after World War II was responsible for an increase of about 39.7 per cent in this cost. The coal clauses in power rate schedules were chiefly responsible for this increased cost of electricity. The improvements in the art of generating electricity have advanced so greatly that it required only about 38.4 per cent as much coal to generate a kilowatt-hour of electricity in 1948 as was required in 1920.

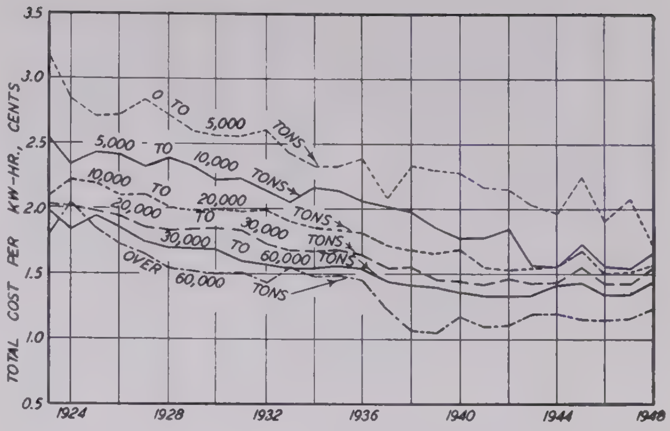

Figure 4. Total cost of power per kilowatt-hour

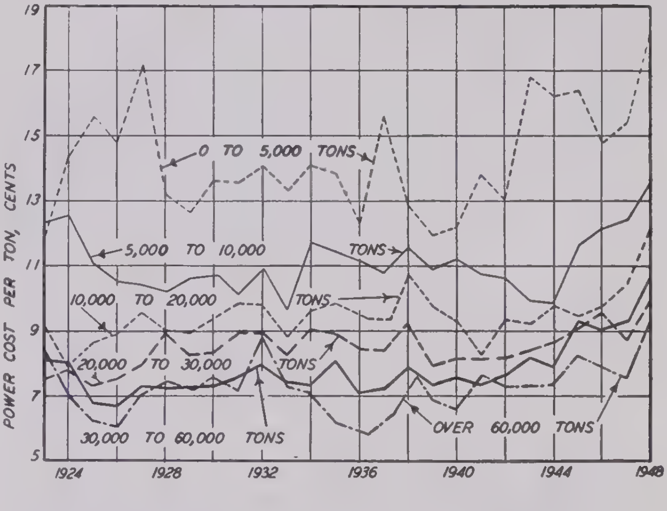

Figure 5. Power cost per ton of coal mined

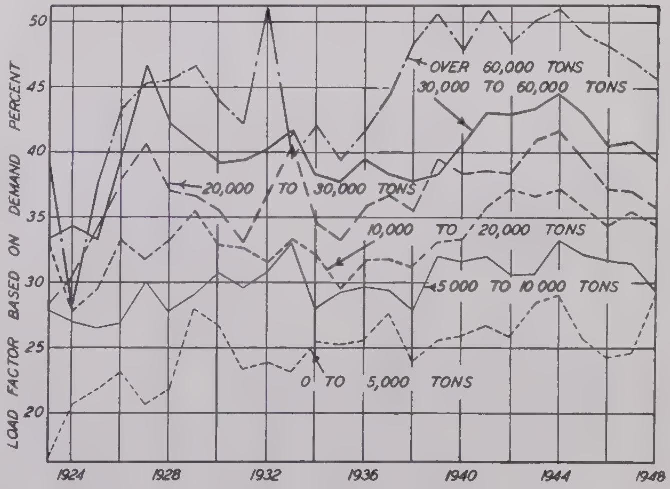

Figure 6. Average power factors of producing mines

Power Costs Per Ton of Coal Mined. The net result of progressively lower costs for each unit of electricity purchased, and of increased amounts of electricity used in mining each ton of coal, has been an almost constant or unchanging cost of power per ton of coal mined for all classes of mines over the period from 1923 to 1942 (Figure 5). There has been an upward trend in cost of power per ton of coal mined since the beginning of World War II, and it is likely that the culmination of this marked increase in power cost will be seen soon.

There is a great difference in the power requirements and costs of the different tonnage classes (see Figure 5). The mines included in the 0 to 5,000 tons per month have the highest power cost per ton of coal produced. This group of mines having small monthly production includes many mines nearly worked out, in which case, pumping, ventilation, and haulage costs are high. New mines may have lightly-loaded electric equipment. The power costs per ton of the group producing 0 to 5,000 tons per month are approximately twice as great as the average power costs of mines producing over 60,000 tons per month. The mines producing large monthly tonnages have many opportunities to minimize power costs, such as being able to load the electric equipment fully, purchase electricity at a high load factor, and buy most of the energy used in the low-cost blocks.

Load Factor of Power Purchases. A simple definition of load factor with reference to power purchases is the relation of the average hourly rate of power use during a period of a month, to the highest rate of power use during any 15-minute or 30-minute demand interval of the same month. Power rates vary considerably in specifying the basis of maximum demand, but the term as used in this article is simply the relation of average demand to maximum demand for a monthly period.

Load factor is extremely important because modern power rates determine the cost of electricity more on the basis of load factor than on the quantity of power purchased. For this reason, the well-managed mine usually has a high load factor, and much attention and effort are devoted to controlling or limiting maximum demand. A set of curves showing the trend of average power factors maintained by the various tonnage classes of producing mines has been prepared (Figure 6).

In general, all the groups of mines have succeeded in improving the load factor of their purchases. The large mines are able to maintain the best load factors due to the greater diversity of their many power requirements. This is one of the main reasons why power costs are proportionally less to the large tonnage mines.

To summarize, the data for the last 26 years clearly show the increasing use of electricity in bituminous coal mining brought about chiefly by increased mechanization and the decreased cost of electricity per kilowatt-hour; the result of both of these trends is an almost constant cost per ton. Also, the continued trend away from private steam plants to central-station power is quite pronounced.

Stackable Carrier Telephone System

L. G. ERICKSON
MEMBER AIEE

D. G. CLIFFORD

Many of the independent telephone companies in the United States need an economical means of obtaining short-distance carrier circuits. The 3-channel stackable system, while coordinating with other systems of conventional channel allocation, may be installed as service demand requires, one channel at a time, each channel independent of the others.

IN 1935 it cost about $150 to install one mile of conventional open-wire communication pair including wire, insulators, and labor, on an existing pole line with poles, crossarms, and pin space available. Today it costs about $500 to duplicate this same mile of communication pair. In 1935, if a 3-channel carrier system were used over a 50-mile circuit, the cost would have been approximately $550 per mile—more than the cost of wire-line construction. At present, over the same circuit, carrier equipment costs less than $100 per mile, or about one-fifth of the cost of new wire construction. Therefore the same carrier system can be applied now to circuits less than ten miles long and still be economical. These cold economic facts are responsible for the greatly increased demand for carrier equipment. As a corollary, the greater the demand, and hence volume of production, the less the cost of the equipment.

At present the market open to the independent manufacturer of carrier communication equipment is comprised principally of the independent telephone companies, the oil and pipe-line companies, the public utilities, and the railroads. The independent operating telephone companies exist largely as clusters of exchanges serving a particular section of a state. Until recently the majority of them relied on physical circuits to provide intercity or intertown circuits. Mounting costs of wire-line construction, ever increasing demand for more circuits, and the availability of relatively inexpensive carrier equipment have meant that

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Essentially full text of conference paper, "A 3-Channel Stackable Carrier Telephone System," presented at the AIEE South West District Meeting, Dallas, Tex., April 18–21, 1949.

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the economic way of providing additional facilities has been installation of carrier channels. Since the majority of these companies rely on the Bell System for long-distance toll trunking, their requirements are primarily for so-called short-haul carrier circuits. There are, of course, exceptions, and many independent companies operate long-haul carrier circuits, but short-haul carrier circuits predominate. On the other side of the picture, oil and pipeline companies, railroads, and public utilities such as gas and electric companies, operate medium and long-haul circuits and short-haul local circuits, extensive telegraph networks in the case of the railroads, and telemetering circuits in the case of oil companies and utilities. In many of the applications of all these users there is a distinct advantage in such frequency allocations and equipment designs as will permit an initial installation of only one channel and the subsequent addition of channels as the need arises.

GENERAL OBJECTIVES

The type-*33* carrier system was designed with the following objectives in mind.

1. The equipment should provide for the addition of up to three additional channels over existing voice-frequency wire-line circuits. Furthermore, it should be feasible to install initially one, two, or all three of these channels on a proportionate cost basis.
2. The frequency allocation utilized should co-ordinate with existing widely-used carrier systems.
3. Its cost should be low enough to justify use on circuits down to ten miles in length; yet it should have a sufficiently high gain to enable working on long circuits.
4. Repeaters and preferably automatic level regulation equipment should be available to permit stable operation on long-haul circuits.
5. The signaling equipment should be equally adapted to a-c ringdown, d-c ringdown, or dial operation, and should be readily convertible from the initially-required type of operation to another type.
6. The design of the equipment should be such as to facilitate installation, lineup, and maintenance by nontechnical personnel.

CHOICE OF OPERATING FREQUENCIES

A fundamental decision in the design of such a system is the choice of operating frequencies. With a considerable variety of carrier systems operating in the same general spectrum allocations, crosstalk control is a delicate matter.

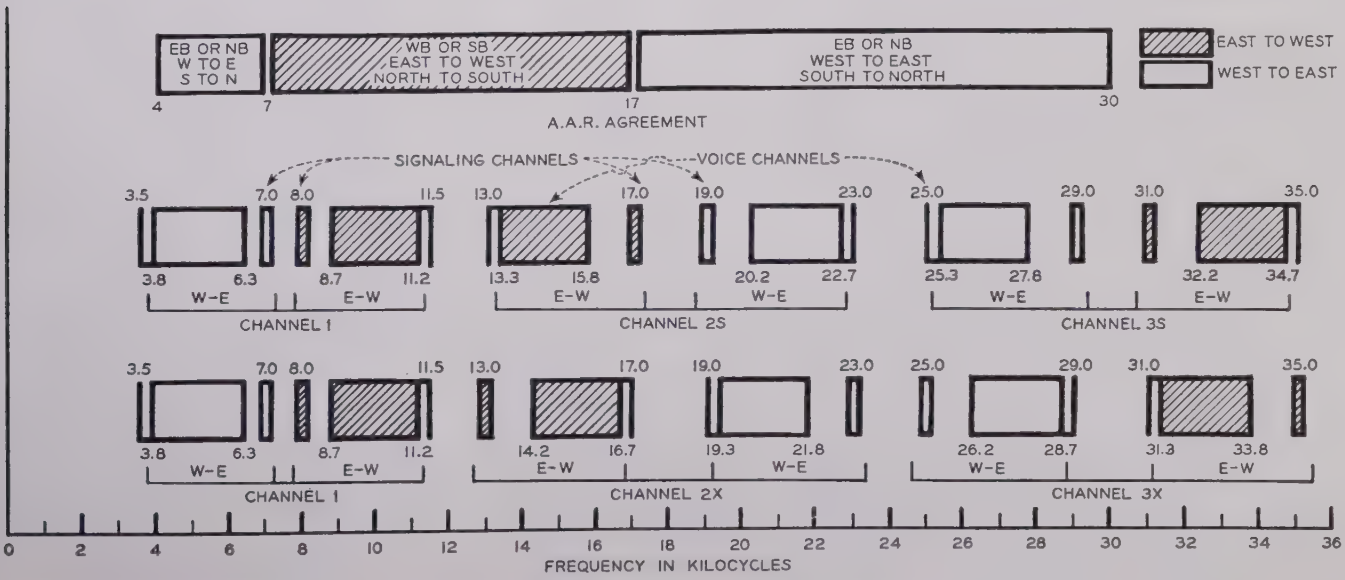
Figure 1 shows the frequencies chosen for the new system. The top line gives the frequency allocation of the Association of American Railroads convention, the guiding pattern of all low-frequency carrier development in the United States. The second row shows the frequency allocations of the *33* stackable system. By choosing frequencies as shown, stackable characteristics are obtained with co-ordination. Use of upper and lower sidebands as shown is to permit optimum location of signaling frequencies. The actual final choice of frequencies was based on consideration of the magnitude of intermodulation products and their location. The third row of frequencies shows the frequency allocation of the same system with inverted sideband translation. This system is used when two 3-channel carrier systems are used on the side circuits of a phantom group and reduces residual crosstalk to unintelligibility.

It is relevant certainly to mention some of the problems of intermodulation distortion. In block grouped systems using transmitting levels of +18 decibels below one milliwatt and minimum receiving levels of −16 decibels below one milliwatt, a level difference exists in the common high-frequency line of 34 decibels. If intermodulation near-end cross talk in the channels is to be maintained 65 decibels below signal, intermodulation products must be held to levels around −100 decibels below one milliwatt. Requirements for a stackable system are even more rigorous than for the conventional 2-block systems, since no discrimination is offered by the directional filters to spurious frequencies generated in the transmitting branch before they reach the receiving branch. In the stackable system, all transmitting and receiving channels are connected to a common line which also carries signaling and pilot frequencies. With careful attention to choice of core materials, filter design, and allied factors, the required crosstalk levels are obtained even without the discrimination contributed by the blocking filters used in the conventional 3-band system.

Figure 2 shows functional diagrams of a terminal panel

Figure 1 (below). System frequency allocation

X—Inverted *S—Standard*



and of a signaling panel, and indicates how the component panels are connected to make a stackable system. A 3-channel system would utilize three terminal and three signaling panels paralleled as indicated. The method of interconnection of pilot regulator panels, available for channels *2* and *3*, is shown. Individual channel amplifiers, utilized when transmitting levels of +18 decibels above one milliwatt are desired, are not shown but are connected between the transmitting band-pass filter and the directional filter jacks of each channel. Figure 3 illustrates the utilization of component panels of the *33A* system to provide signaling and voice channels between point *A* and points *B*, *C*, and *D*. In this example, channels are selectively terminated so as to provide carrier channels between points *A-B*, *A-C*, and *A-D*. A wide variety of possible combinations facilitates meeting of almost any circuit requirement.

Figure 4 shows the equipment layout of a typical combination of terminal and signaling panels. All equipment is mounted on the front side of the rack mounting panel with all circuit points readily accessible for maintenance checks.

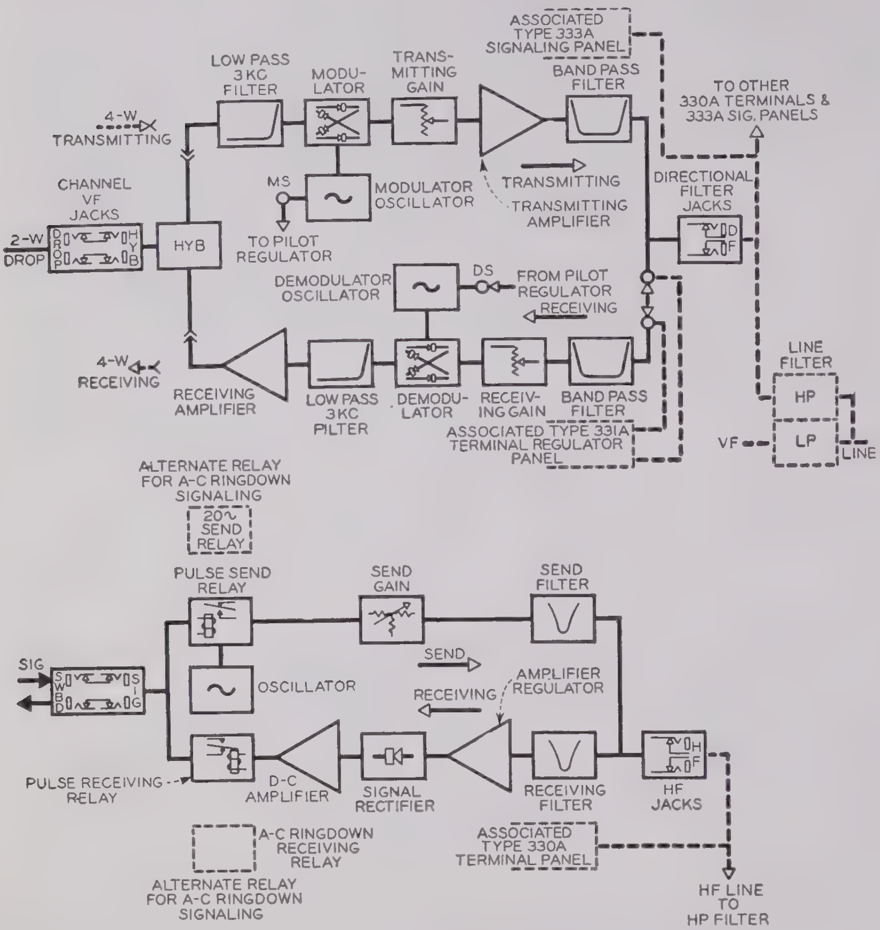


Figure 2. Terminal panel (above) and signaling panel (below)

It will be noted that the filter terminals are well insulated from the metal sides of the containers. Similar precautions are taken inside the filter can as regards clearances and element breakdown ratings. All line filters are designed to withstand longitudinal peak voltages of 3,500 volts and transverse voltages of 1,600 volts. This provides an exceptional safety margin to line surges due to voltages induced by fault currents in paralleling high-voltage circuits and by lightning surges. This feature is of particular value to utilities whose lines are exposed to high voltages.

SIGNALING TERMINAL

The objective set up for the signaling terminals primarily concerns universal application to a-c ringdown, d-c ringdown, or dial operation so that they can be converted readily from one type of operation to another. The type of signaling terminal operation chosen is essentially a high-frequency, amplitude-modulated telegraph channel. Frequencies were selected with regard to filter requirements and consideration of possible intermodulation products.

In the receiving branch of the terminal, the signaling tone to be received is selected by the signal receive filter, amplified, compensated for variations in received levels, rectified and applied to the grid of the tube, *VC1*, holding the receiving relay closed. For a-c ringdown operation, there are two types of operation which are possible. For tone-on operation, tone is transmitted continuously except when a ring is to be transmitted. This method of opera-

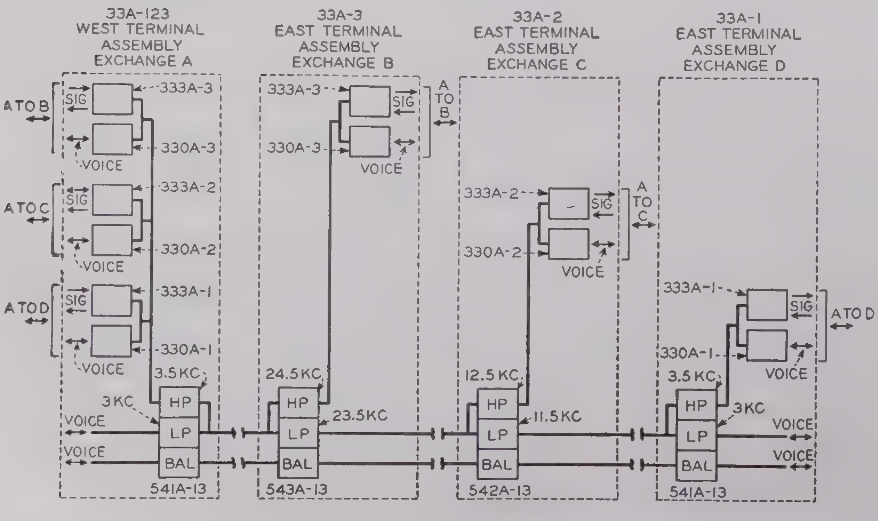

33A-123 WEST TERMINAL ASSEMBLY EXCHANGE A
33A-3 EAST TERMINAL ASSEMBLY EXCHANGE B
33A-2 EAST TERMINAL ASSEMBLY EXCHANGE C
33A-1 EAST TERMINAL ASSEMBLY EXCHANGE D
A TO B
SIG
333A-3
330A-3
VOICE
A TO C
333A-2
330A-2
A TO D
333A-1
330A-1
3.5KC
3KC
24.5KC
23.5KC
12.5KC
11.5KC
HP
LP
BAL
541A-13
543A-13
542A-13
541A-13

Figure 3 (left). Typical 3-channel type 33A system with drop channels

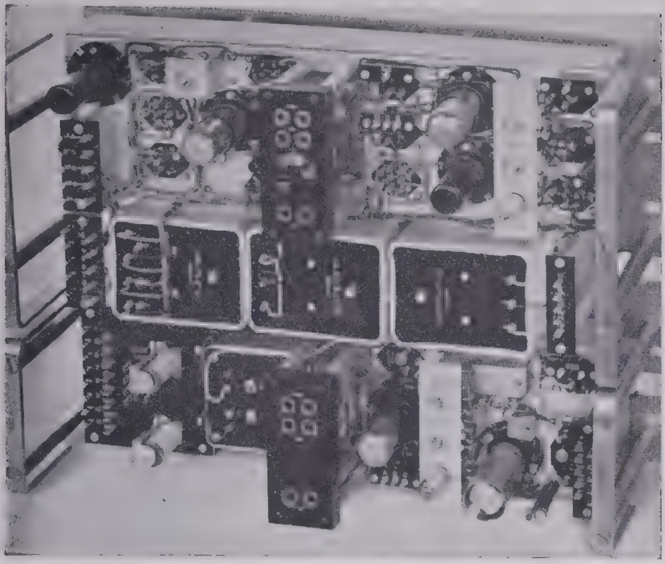


Figure 4. Equipment layout of terminal and signaling panels

tion gives a very high degree of freedom from false signaling due to bursts of noise on the line, and provides for direct supervision of the operation of an unattended remote carrier terminal. Failure of power or of the line is indicated by a continuous signal at the attended terminal. Tone-off operation may be preferred going toward a remote unattended terminal where failure of line facilities would cause a steady ring at the remote drop if tone-operation were used. For dialing service, tone is not transmitted when the channel is not in service. When the channel is seized by the automatic equipment, tone goes over the line, is interrupted to transmit dial pulses, remains on during use to provide supervision, and goes off when the circuit is released. The receiving relay, in conjunction with a suitable appliqué unit, performs required functions at the receiving terminal.

PILOT REGULATION

As one of the general objectives, the need for pilot regulation and repeaters was stressed. Consideration of experiences gained in performance of single-channel, medium-haul systems indicated that pilot regulation was not necessary for the first channel. Therefore, this equipment is available only for channels *2* and *3*. Since the stackable system regulator handles only one carrier channel, the twist within this restricted range is neglected.

Figure 5 shows a block diagram of the pilot regulator. The transmitting branch of this panel obtains the pilot frequency to be transmitted from the transmitting carrier frequency oscillator on the associated terminal panel, since the otherwise suppressed carrier frequency is used as the pilot regulation frequency.

In the receiving branch of the regulator, regulation of level is accomplished by control of the trans-hybrid loss of a hybrid bridge, one arm of which contains a current-sensitive resistor. The band of frequencies to be regulated, containing the desired sideband, pilot, and signaling frequencies, are selected by the channel band-pass filter, attenuated equally by the trans-hybrid loss, and are reamplified by the regulator amplifier. Bridged across the output of the regulator amplifier is a narrow-band filter which selects the pilot frequency. This is amplified, rectified, and made to control the plate current of tube *VB-2*. As this current changes, the lamp-filament temperature—and thus the resistance—varies, and the trans-hybrid loss is altered. Any change in received pilot frequency level is then sensed by the regulator and changes are made to hold the output voltage of the unit essentially constant. A total range of received level of 20 decibels is held constant at the output of a repeater or at the terminal drop circuit within ±2 decibels. Regulation is continuous but delayed to prevent hunting by the thermal lag of the current-sensitive resistor.

The use of the channel carrier frequency as the pilot frequency makes possible automatic synchronization of the overall channel. Since the pilot frequency has been selected and amplified, it exists before rectification at an adequate level for use as the demodulation carrier frequency for injection to the demodulator. This automatic synchronization is of significance when frequency-modulated telegraph is to be transmitted over the carrier channel.

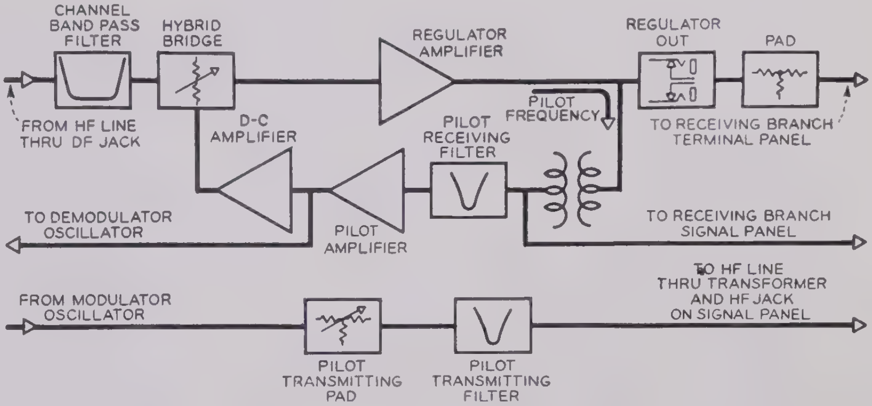

CHANNEL BAND PASS FILTER
HYBRID BRIDGE
REGULATOR AMPLIFIER
REGULATOR OUT
PAD
FROM HF LINE THRU DF JACK
D-C AMPLIFIER
PILOT RECEIVING FILTER
PILOT FREQUENCY
TO RECEIVING BRANCH TERMINAL PANEL
TO DEMODULATOR OSCILLATOR
PILOT AMPLIFIER
TO RECEIVING BRANCH SIGNAL PANEL
TO HF LINE THRU TRANSFORMER AND HF JACK ON SIGNAL PANEL
FROM MODULATOR OSCILLATOR
PILOT TRANSMITTING PAD
PILOT TRANSMITTING FILTER

Figure 5. Block diagram of pilot regulator

Since the repeater amplifier panel already incorporates the requisite band filters, no additional filters are required for the repeater pilot regulator. Two independent hybrid bridges and associated amplifiers are provided on this panel.

The design of the system around functional panels offers great flexibility in the choice of combinations of standard units to meet the special requirements of any installation in an effective and economical way. Loop gain of the basic terminals is relatively high, sufficient to operate moderately long-haul service, and is increased whenever channel amplifiers and pilot regulators are used. Effective pilot regulation insures maintenance of constant level, and automatic synchronization offers important advantages, particularly when frequency-modulated carrier telegraph or telemetering is transmitted over a carrier channel.

Design of Insulation for Small Machines

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E. M. STANBERY

INSULATION systems for small rotating machines largely have been designed by empirically applying past experience of the industry. In general, very high factors of safety are employed and exact design of the insulation for the stresses involved have not been important.

In aircraft electric apparatus, high altitude results in increased insulation stress. This, together with the need of obtaining maximum performance for a given size and weight, means that insulation for such machines should be designed to be adequate without using unnecessary space.

An investigation was made to determine a means of designing insulation scientifically for any specified voltage and altitude. In order to do this, it was necessary to find the cause of insulation deterioration and failure. It was suspected that corona might be the cause of early failure at high altitudes. An investigation by visual means indicated that corona could exist at a few hundred volts even at sea level and that the voltage necessary to start the corona discharge decreased with an increase in altitude.

A paper by G. E. Quinn,[1] gave the clue to the exact determination of the voltage at which corona discharge started. This was based on the high-frequency oscillations which are associated with the corona discharge. A test setup using a modification of Mr. Quinn's circuit proved that corona could be checked accurately both in the actual windings of aircraft electric machines and in test coils which were easily constructed with the desired insulation.

It was thought originally that the kind of insulation as well as the thickness would be important. It was found, however, that for the usual kinds of insulating material, such as paper, cotton, silk, and the usual plastics, the dielectric constant was near enough alike so that a common curve of corona starting voltage against insulation thickness for any altitude could be drawn. Curves of variation of corona starting voltage against altitude also could be drawn (Figure 1). It was found that a variation of frequency had a negligible effect on corona starting voltage. This then, provides a basis of design of insulation if it could be proved that early insulation failure could be correlated with corona starting voltage.

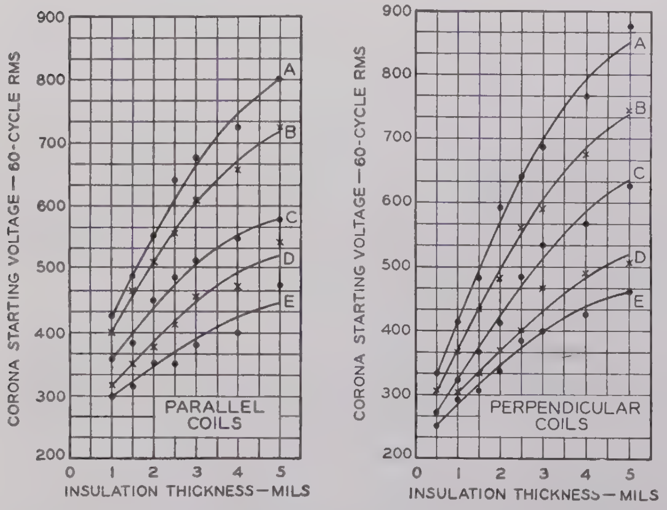

Figure 1. Corona starting voltage at various altitudes for varying thickness of insulation; (left) coils parallel, (right) coils perpendicular

A, atmospheric pressure; B, 10,000 feet; C, 20,000 feet; D, 30,000 feet; E, 40,000 feet

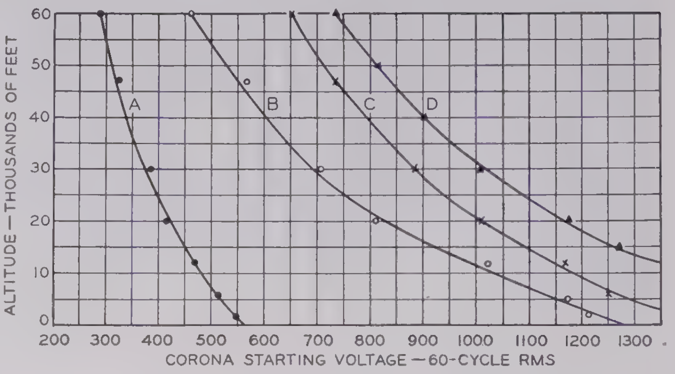

Figure 2. Corona starting voltage with several thicknesses of insulation at varying altitudes

Insulation thickness: A, 0.0025 inch; B, 0.0075 inch; C, 0.011 inch; D, 0.014 inch

A series of tests were arranged on an aircraft dynamotor first holding a constant output of 1,150 volts d-c and varying the altitude. Another series of tests were run at 27,500 feet and with varying voltages. See Figure 2. Approximately 50 machines were run to destruction under these varying conditions. A good correlation of life and corona starting voltage was obtained so that it is believed that insulation operated below the corona starting voltage will have good life provided that temperature is within limits.

This method of designing insulation for small rotating machines has been used on numerous designs since the work was started. A minimum safety factor of 40 per cent was used. These designs have all proved to be adequate.

The corona starting voltage test may be used as a quality control check for production testing to indicate defective or misplaced insulation. It is believed that this is more valuable than a high-potential test in determining that a machine has no insulation faults.

REFERENCE

1. A Method for Detecting the Ionization Point on Electric Apparatus, **G. E. Quinn.** AIEE *Transactions*, volume 59, 1940, pages 680–2.

Digest of paper **49-213**, "The Design of Insulation Systems for Small Rotating Machines by the Determination of Corona Voltage," recommended by the AIEE Committee on Air Transportation and approved by the AIEE Technical Program Committee for presentation at the AIEE Pacific General Meeting, San Francisco, Calif., August 23–26, 1949. Not scheduled for publication in AIEE *Transactions*.

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The Electric Discharge of the Electric Eel

M. V. BROWN

Because it is the most powerful electrically of the fishes, and because it breathes air and thus can be kept out of the water for a period of time, the eel has proved an ideal subject for the study of the nature of energy sources in animals. In this article, the second in a series,* the author analyzes the electric discharge of the electric eel.

THE ELECTRIC EEL, *Electrophorus electricus*, delivers the most powerful electric discharge of any electric fish. In addition, it breathes air and can therefore be kept out of water for long periods of time. For these reasons it has proved ideally suitable for the pursuing study of "animal" electricity.

The discharges recorded by an oscillograph whose terminals make contact with the body of an eel are fundamentally the same as those recorded when those same terminals are connected to any other living tissue. But the magnitude of the effect is enormously different. If, for example, one attempts to observe the voltages generated when a man flexes the muscles of his hand, high amplification is needed and great care must be exercised to eliminate "pickup" in the leads. An eel, however, generates several hundred volts and no amplification is needed, and there is no need to worry about "pickup" or contact potentials.

These disproportionate magnitudes might lead one to think that the two phenomena are unrelated. However, they are essentially similar. Muscles are controlled by the motor end plates in which the motor nerves terminate. The electric tissue of the eel is thought to be muscle in which the contractile tissue has disappeared, leaving only a large concentrated mass of motor end plates. Therefore, facts learned by the study of such tissue are directly applied to the theory of nerve behavior.

A single end plate develops only about 0.1 volt, but in the electric tissue of the eel, the cells are arranged in a series parallel array. For this reason an adult eel can deliver considerable power. On open circuit the discharge reaches a peak of 400 to 600 volts. On short circuit the external current is of the order of one ampere. At maximum power one may draw an external current of about one-half ampere at 200 to 300 volts, that is, 100 or more watts. However, these discharges occur in short pulses lasting about 0.003 second, and the power averaged over a period of minutes seldom exceeds 1/30 of a watt.

As can be seen in the oscillographic trace shown in Figure 1, these pulses are released in short trains. The minor pulse leading the train is typical. This small pulse is generated by a minor pair of electric organs called the "bundles of Sachs." From Figure 1 it can be seen that no two pulses are ever quite alike. The degree of irregularity varies with physical condition and fatigue as well as from eel to eel. Because of this irregularity, a large number of observations must be averaged in order to obtain significant results. This difficulty is typical of biological investigations, for nothing is more characteristic of living tissue than its incapability to repeat. In Figure 2, the time scale has been expanded to show the shape of the pulse. The discharges are released at the will of the eel either as a defense or to stun small fish for food. Under moderate stimulation an eel will discharge 500 times a minute, but frequently more than 100 discharges per second have been observed.

We have undertaken to establish the electrical characteristics of the discharge of an eel. A knowledge of the manner in which the electromotive force and internal resistance vary is essential if one is to evaluate the various

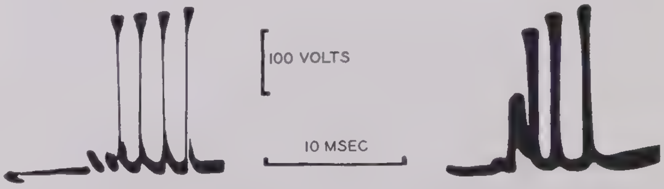

Figure 1. Two trains of discharges

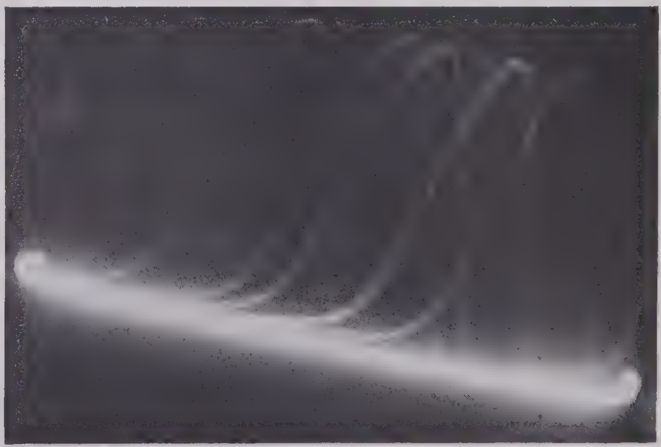

Figure 2. A train of discharges, in which the time scale has been expanded to show the shape of the pulse

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Essentially full text of a conference paper, "An Analysis of the Electric Discharge of the Electric Eel," presented at a Conference on Energy Sources held during the AIEE Winter General Meeting, New York, N. Y., January 31–February 4, 1949, and illustrated by demonstrations with live eels. This paper is based upon work done at the New York Aquarium during a period of several years by R. T. Cox, Professor of Physics, Johns Hopkins University, C. W. Coates, Director of the New York Aquarium, and M. V. Brown.

M. V. Brown is Assistant Professor of Physics, The City College of New York, New York, N. Y.

* See "Electric Eels," C. W. Coates (*EE, Jan '50, pp 47–50*) for the first article in this series.

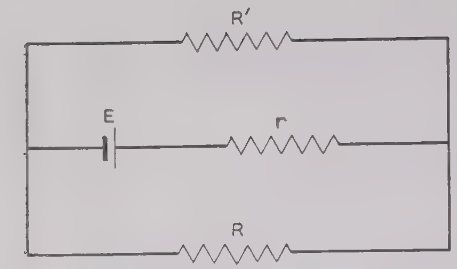

Figure 3. Simplified electrical model of eel's discharge

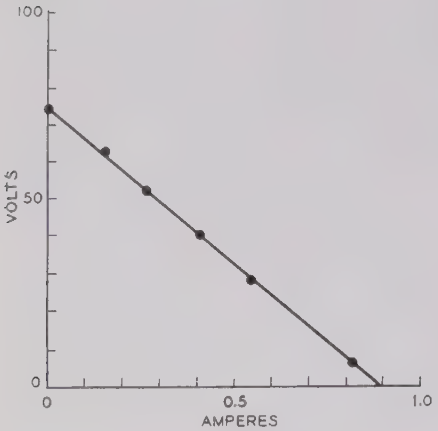

Figure 4. Plot of peak external voltage against external current

hypotheses as to the mechanism of discharge. Much can be learned by a study of live undissected fish.

In one set of experiments two aluminum strips were placed ten centimeters apart and each one centimeter wide beneath the body of an eel as it rested on a wooden trough on a laboratory table. (Large area electrodes are necessary in order to avoid burning the skin of the eel.) These electrodes were connected to the vertical deflection plates of an oscillograph and the discharges were recorded photographically. Varying amounts of power were drawn from the eel by connecting resistances varying from 50 to 400 ohms in parallel with the oscillograph.

The resultant data were interpreted by assuming the simplified electrical model shown in Figure 3. In this model E is the effective electromotive force of the 10-centimeter segment of electric tissue, and r is the effective internal resistance. R' is the effective resistance of all closed circuits within the nonelectric tissue of the fish, and R is the external load. In actual fact, the tissue is a complex network of electromotive force and resistance. The substitution of the simple model is justified by Thevenin's theorem. The application implicitly assumes that E, r, R', and R are independent of the current.

The validity of this assumption is attested by Figure 4 in which the plot of peak external voltage against external current appears as a straight line. Figure 5 is a similar plot in which simultaneous values of voltage and current are plotted not only for the peak of the discharge but also for instants 0.2, 0.4, 0.6, 0.8, and 1.0 millisecond after the peak of the discharge. The top line corresponds to the peak; the first line below to an instant 0.2 millisecond later, and so forth.

The slope of the lines is $r'=\dfrac{rR'}{r+R'}$, and the point at which their extrapolations intersect indicates the electromotive force. It is seen that the electromotive force remains sensibly constant at about 150 volts while the internal resistance, $r=\dfrac{r'R'}{R'-r'}$, rises sharply.

Figure 6 is a similar plot relating to the rising phase of the pulse. The top line relates to the peak of the pulse; the one just below it to an instant 0.1 millisecond before the peak, and so forth. Here we see that the internal resistance is roughly constant while the electromotive force appears to rise. Other fish give similar curves, though no two individuals are ever quite alike.

From these data it would seem that the pulse is initiated by the sudden appearance of an electromotive force and terminated by a rapid rise of internal resistance. Further study of the first moments of initiation and the last of termination are required. Very likely, one should find a drop of resistance preceding the rise in electromotive force.

We have evaluated the total electric energy released per impulse in terms of our model. These measurements correlate favorably with chemical analyses made by D. Nachmansohn and M. A. Rothenberg, indicating that phosphocreatine is the immediate source of energy from which the electric cell is restored and readied for discharge. The chemical mechanism of the discharge itself is still conjectural.

The electric energy produced per unit of volume depends

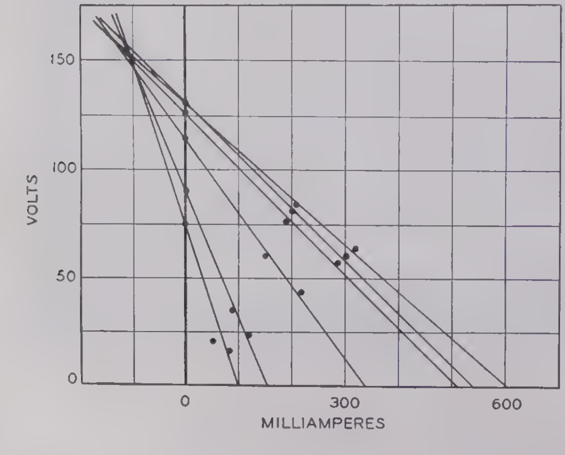

Figure 5 (left). Plot similar to that of Figure 4 as related to the falling phase of the pulse

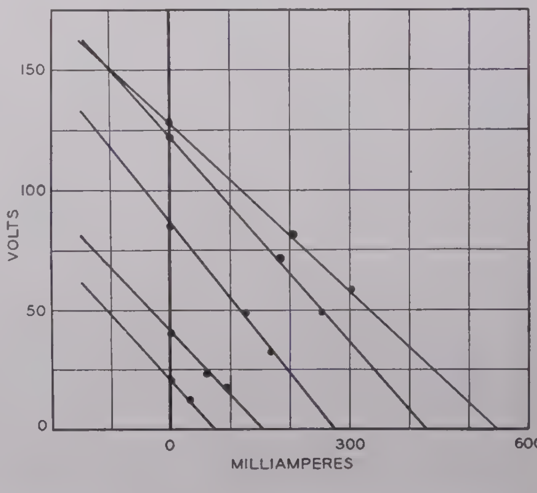

Figure 6 (right). Plot similar to that of Figure 4 as related to the rising phase of the pulse

upon the size of the eels, being greater for small than for large eels. This is because, as the over-all size increases, the end plates increase in size, resulting in fewer plates per unit of length. The electric energy produced per cubic centimeter of tissue is 370 microjoules per impulse in a 60-centimeter eel and only 100 microjoules per impulse in a 180-centimeter eel.

A number of interesting models have been proposed for the electric tissue; one is shown in Figure 7. The boxes represent cells in series. The boundary *A*, indicated by a double line, is a seat of electromotive force. The double dotted line represents a boundary membrane, *B*, whose resting resistance is very high but whose resistance drops to a low value during the discharge. The polarizations shown correspond to the resting condition when no external voltage is observed. Here the dotted membrane resembles a capacitor in that it bears opposite charges on its two faces. It is assumed that the potential difference produced by the charged condition of layer *B* is just sufficient to offset the electromotive force of *A*.

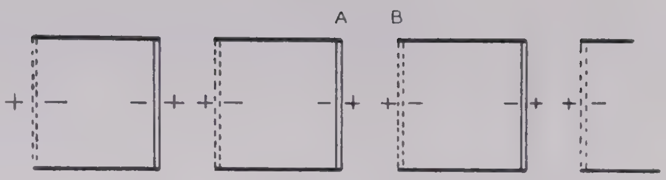

Figure 7. A schematic model of electric tissue

If this membrane, *B*, were to have a temporary drop of resistance, a discharge would begin in which the disappearance of charge on the "capacitor" would be reflected as an externally observed rise in apparent electromotive force. The later rise in resistance would be observed as an increase in "internal resistance" and no polarization charges would appear on *B* to reduce the apparent electromotive force until the resistance had reached a value so high as to have reduced the externally observed "terminal voltage" to a value little short of zero.

Thus this model would qualitatively account for our data. It remains to refine the data so that quantitative checks can be made on proposed chemical mechanisms which might account for the electromotive force and the changes of resistance.

If such a mechanism can be developed it may have important commercial applications, for nature's mechanism is one which can, in electric tissue, produce relatively large amounts of electric energy per unit volume in two or three milliseconds.

New Electronic Statistical Machine to Be Used in Census

Analysis of the vast amount of numerical data to be collected in the forthcoming national census, will be performed in part by the Electronic Statistical Machine, which was recently presented to the Bureau of the Census by the International Business Machines Corporation. This new machine combines in one operation the simultaneous functions of classifying, counting, accumulating, and editing. The machine then prints the statistical data resulting from groupings of information and automatically balances the totals to insure their accuracy.

As an example of how the equipment's editing function would work, a card might indicate through error that an 8-year old boy was a war veteran. Thereupon, the machine's editing feature would automatically reject this card.

The Electronic Statistical Machine has speed as well as versatility. It has a capacity for counting up to 10,000 units in each of 60 different classifications while simultaneously sorting the cards into predetermined groups at the rate of 450 cards a minute. Totals for major classifications can be broken down simultaneously into smaller classifications. For example, the total number of farms in a state can be counted at the same time that they are broken down into as many as 60 size and ownership ranges.

The new machine is equipped with two separate printing mechanisms which operate in a manner similar to a typewriter carriage. These allow the machine to print on a single line not only the totals for each of the 60 groups, but also the grand totals. As a further check for accuracy, the printed totals of each of the 60 groups are balanced automatically against the grand totals. At the same time these other operations are being performed, all of the information can be relayed automatically to another machine connected by cable to the statistical machine, and punched into cards which are used later in the preparation of still other statistical reports.

Census data regarding America's 150 million people, 45 million homes, and 6 million farms will be recorded on 270 million punched cards—one for every person, one for every dwelling unit, and eight or more for every farm.

The task of transferring the basic facts from census questionnaires to the cards by means of key punch machines will take about a year. Approximately two million cards will be punched per day at the peak of operations.

Classifying, counting, and tabulating the results will be completed by the Spring of 1952. It is estimated that this operation will be equivalent to running 10 billion cards through one machine.

The Seventeenth Decennial Census will cover agriculture, population, and housing. The enumeration will start on April 1, 1950, and will take about two weeks to complete in urban areas and about a month in rural sections. Agriculture Census forms will be distributed to farmers by mail in most states in advance of the population enumeration and the completed forms will be picked up when the enumerators come around to ask the population and housing questions.

Lightning Stroke Damage to Aircraft

J. H. HAGENGUTH
MEMBER AIEE

DO LIGHTNING STROKES represent a danger to airplanes? To determine this possibility was the object of a number of investigations made in collaboration with the National Advisory Committee for Aeronautics under the direction of Dr. K. B. McEachron between 1938 and 1942.

The nature of cloud-to-ground strokes was beginning to be well understood at that time. These generally consist of one or more current peaks—high current discharges of microsecond duration—and continuing current discharges with an amplitude of a few hundred amperes which may last as long as a second and a half. Cloud-to-cloud strokes—from photographic evidence and theoretical considerations—probably are principally of the continuous current type. The continuous current type of discharge burns holes into the skin of airplanes, in the rudder bow, the trailing edges of ailerons as shown in Figure 1, the Pitot tubes for measuring air speeds, and may burn off trailing antennas.

Thus, an average stroke of 20 coulombs would burn a hole of about 40 square millimeters in a 20-mil sheet. The results are approximately the same for copper, aluminum, galvanized iron, and stainless steel.

From lightning burns on airplanes it appears that as many as 500 coulombs can be conducted in a lightning discharge. In one such case a high-current peak of at least 100,000 amperes must have been involved, judging from laboratory tests made to produce similar damage. In spite of the damage produced, the airplanes were not disabled. The possible source of danger in the case of fuel tanks is the burning of a hole, with consequent burning of the gasoline, or even explosion.

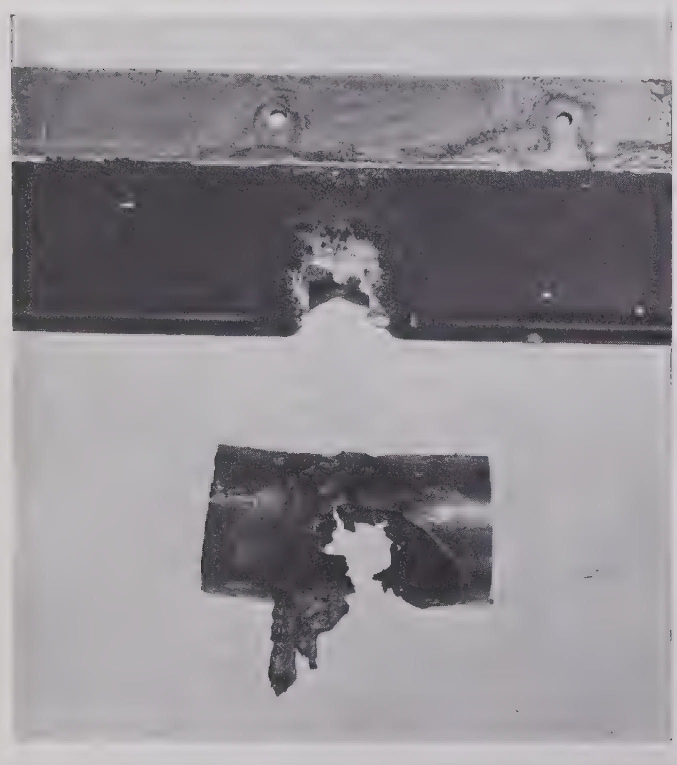

Figure 1. Holes burned in wing edge (top) and a rudder bow (bottom) by natural lightning

Estimated 300 coulombs in lightning stroke for both cases

The tests with continuous current arcs to the tank below the liquid level produced holes of much smaller size than in an empty tank, and did not result in an explosion nor did flames always occur. The hole size was about the same when the tank was filled with water.

Explosions with aviation gasoline resulted only in a temperature range of from −20 to −40 degrees centigrade. These explosions ruptured the tank. Damage to the tank could be prevented by sufficient venting to the atmosphere.

Another cause for accident might be the shattering of the windshield by strokes. The psychological and physical effects on the pilot are self-evident. Only current peaks could be responsible for such damage.

Safety glass consisting of two 1/8-inch glass sheets bonded by a plastic filler requires current crests of about 175,000 amperes to even crack one of the glass plates with the discharge only two to three inches from the glass. Discharges of 235,000 amperes were needed to crack both glass plates, but the plastic filler was not ruptured. However, the force of cracking the inner plate was sufficiently great to drive glass splinters into the back of the wooden box in which the glass was mounted. The glass and plastic filler could be broken if the spark penetrated through the safety glass.

Due to the relatively small size of the windshield completely surrounded by metal, the probability of a stroke as close as during the tests is extremely low. The use of automatic pilot and the presence of a copilot should prevent destruction of an airplane due to a broken windshield.

The freezing of ball bearings connecting the control surfaces to the airplane body was found to be due to high current peaks of 40,000 amperes and more. The damage was not sufficient to prevent operation of the controls.

Current peaks, as well as continuing currents, may contribute to blinding of the pilot's vision. This, however, should not be a contributing factor in modern airplanes manned by at least two pilots and equipped with an automatic pilot.

The effects of lightning on nonmetallic airplanes may be destructive unless rather elaborate shielding is used.

This series of tests has shown that although the possibility exists that a lightning stroke may cripple an all-metal airplane, the probability is remote.

Digest of paper **49-214**, "Lightning Stroke Damage to Aircraft," recommended by the AIEE Committees on Air Transportation and Transmission and Distribution and approved by the AIEE Technical Program Committee for presentation at the AIEE Pacific General Meeting, San Francisco, Calif., August 23–26, 1949. Scheduled for publication in AIEE *Transactions*, volume 68, 1949.

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Features of Substation in San Francisco

EINAR NILSSON
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MISSION SUBSTATION, built by the Pacific Gas and Electric Company at Eighth and Mission Streets in downtown San Francisco, is a subtransmission station receiving power at 110 kv and distributing it at 12 kv. It will serve as a source of additional energy to increase capacity and relieve overloaded conditions in the downtown area. Within the building are two 35,000-kva 110/12-kv 3-phase forced oil-, forced air-cooled transformers; a 110-kv transmission ring bus with four 110-kv 800-ampere 5-cycle oil circuit breakers with an interrupting rating of 3,500,000 kva; one section of 12-kv subtransmission bus of the double-circuit-breaker type containing 15-kv, 1,200- and 3,000-ampere air-blast circuit breakers with an interrupting rating of 1,000,000 kva; reactors and cable terminal cells; three sections of 12-kv distribution bus of the main bus transfer bus arrangement containing 15-kv 1,200- and 2,000-ampere magnetic blow-out air circuit breakers with an interrupting rating of 500,000 kva; and thirteen 563-kva ±7$^1/_2$ per cent step-type feeder regulators. Ultimately there will be two 35,000- and two 50,000-kva transformers, seven 110-kv oil circuit breakers in the ring bus, two sections of the 12-kv subtransmission bus, six sections of 12-kv distribution bus, and 24 feeders with step-type regulators. See Figure 1 for the general disposition of the electric equipment.

Load studies showed that additional energy could not be furnished economically from existing major points of supply from increased facilities at 12 kv. The substation location in the downtown area made underground supply to the station the only practical method. Economic studies of various transmission voltages showed 110 kv to be the most economical for the block of power involved. To connect the Mission Substation both to the San Francisco steam generating system and to the main transmission system 110-kv gas-filled pipe-type cables were selected.

Location of a substation designed for an ultimate capacity of 170,000 kva in a congested metropolitan area posed several problems. The cost of the property and building made compactness of design, without adversely affecting reliability, a prime requirement. In addition, close proximity to San Francisco's prominent Civic Center made careful architectural treatment of the building mandatory. In order to achieve compactness and, in this case, low cost, departure was made from the Pacific Gas and Electric Company standard 110-kv double bus. A ring bus was adopted as a compromise. Its flexibility is slightly less than the double bus, but in return its cost is substantially less. The 12-kv subtransmission bus and switchgear was designed, again with compactness, reliability, and accessibility in mind. Current limiting reactors are installed in the subtransmission tie cables, in order to limit the short-circuit stresses that equipment in older interconnected stations will be exposed to, through a large source of power made available in the Mission Substation. A substantial saving was made possible through installing reactors in the feeders to the distribution bus, in that it made possible the use of 500,000- instead of 1,000,000-kva circuit breakers in the distribution feeders.

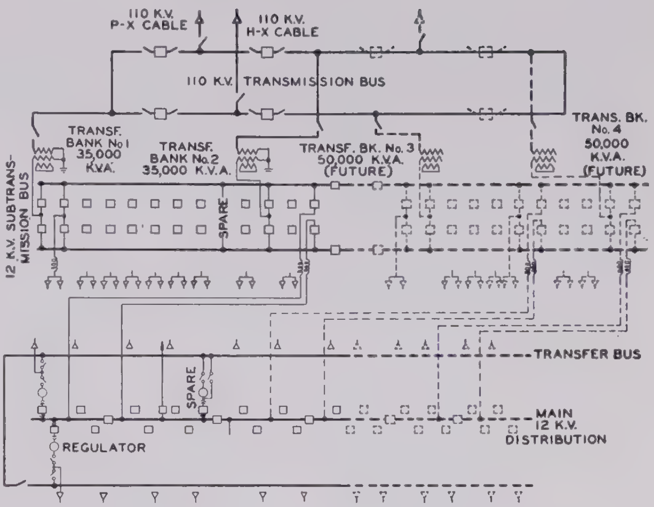

Figure 1. Single line diagram of Mission Substation

Efforts were made to reduce to an absolute minimum the fire hazard associated with oil-filled equipment through the extensive use of air circuit breakers in distribution and tie feeders. Oil-filled equipment is located in fireproof enclosures which are equipped with a fixed water fog fire-fighting installation automatically operated by a temperature rate-of-rise type of fire detecting system.

Station lighting is, in general, of conventional design using both incandescent and fluorescent fixtures. In the past, switchgear aisles have been found difficult to illuminate evenly with incandescent fixtures, and to avoid this, extensive use has been made of industrial-type fluorescent fixtures in these areas.

One of the special requirements for this station, dictated by its close proximity to a large hotel, was soundproofing. The walls and ceiling of the main transformer rooms were covered with a soundproofing material to a thickness of four inches. Also, the transformer foundations were built as structures self-supporting and independent of the rest of the building, thus preventing transformer vibration from being transmitted to the outside. Furthermore, there are no windows in the building, which eliminates another possible path for noise to escape from the interior. The result has been completely satisfactory.

Digest of paper **49-217**, "Electrical Design Features of Mission Substation, a High-Voltage Subtransmission Station in San Francisco," recommended by the AIEE Committee on Substations and approved by the AIEE Technical Program Committee for presentation at the AIEE Pacific General Meeting, San Francisco, Calif., August 23–26, 1949. Not scheduled for publication in AIEE *Transactions*.

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An Electric Deicing System for Aircraft

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FORMATION of ice on aircraft flight surfaces is an occurrence which is of vital concern to any pilot. It is imperative that aircraft be equipped with a satisfactory ice removal system to permit flying in adverse weather conditions. The continued search for satisfactory ice removal systems has entered the electrical field.

A recent experimental airplane (shown in Figure 1) is provided with an electric deicing system in which heat for ice removal is obtained from electric resistance blankets applied to the outside of the airplane's wing, nacelle, and tail leading-edge skin. The resistance deicing blankets are of rubber construction and contain electric resistance-wire as the heating element. The finished blanket is 0.060 of an inch thick with length and width as may be necessary for installation. Recesses, equal to the thickness of the deicing blankets, in the leading edge of the wing, nacelle, and tail surfaces permit a smoothly contoured installation of the blankets.

The rate of heat generation required for ice removal amounts to nearly 4,000 Btu per hour per square foot or an electric power consumption of eight watts for each square inch of blanket area. The total area of deicing blankets on the airplane amounts to approximately 400 square feet and results in a deicing blanket connected load of 452 kw. See Figure 2. In operation the deicing blankets receive power periodically in a repeating cycle with the maximum "on" time for each blanket being one quarter of its total cycle time. Such operation materially reduces the continuous electric power requirements and results in a maximum, continuous deicing load, from the standpoint of generator capacity, of 113 kw.

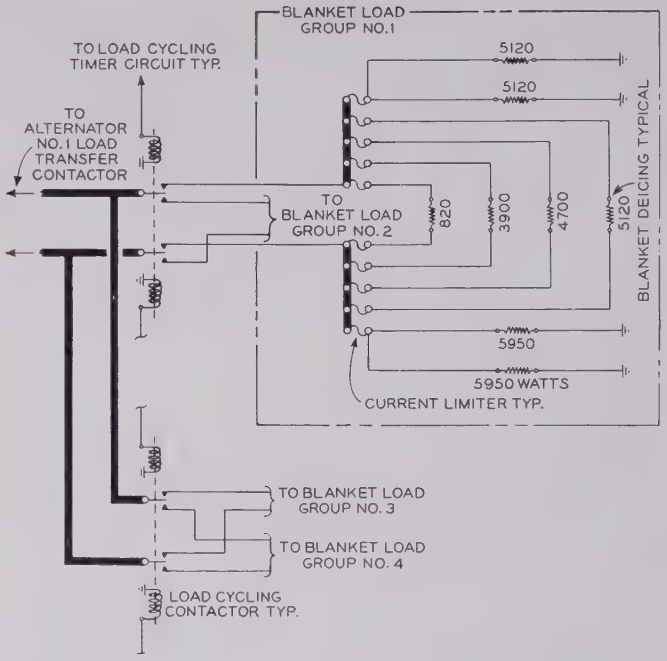
BLANKET LOAD GROUP NO.1
TO LOAD CYCLING TIMER CIRCUIT TYP.
TO ALTERNATOR NO.1 LOAD TRANSFER CONTACTOR
5120
5120
BLANKET DEICING TYPICAL
TO BLANKET LOAD GROUP NO. 2
820
3900
4700
5120
5950
5950 WATTS
CURRENT LIMITER TYP.
TO BLANKET LOAD GROUP NO. 3
TO BLANKET LOAD GROUP NO. 4
LOAD CYCLING CONTACTOR TYP.

Figure 2. **Diagram of typical deicing load for one alternator**

An a-c system is used to power this deicing load with four 208-volt 3-phase 40-kva (at 0.75 power factor) alternators used as deicing power sources. The deicing load is normally supplied from three of the alternators with the fourth machine being used as a spare in event of an alternator failure. The alternators do not operate in parallel but are individually connected to various divisions of the total deicing load. In dividing the deicing blankets into the electrical load divisions, care must be taken so that the ice which forms on the airplane between blanket heating periods will be deposited in a symmetrical pattern with the least disturbance to the airplane's balance and aerodynamic characteristics. The alternators are directly driven by the airplane's engines at speeds between 6,700 and 7,700 rpm, corresponding to frequencies of 447 and 515 cycles per second, respectively, without the aid of constant-speed drives and are operated with a grounded-phase load to provide a 2-wire 3-phase system.

Figure 1. **Artist's conception of airplane with deicing blankets**

The electrical cyclic method of ice protection for aircraft fixed surfaces is the subject of recent and continuing investigation, and this installation is believed to be the first of its kind in the United States.

Digest of paper **49-218**, "An Electric Deicing System for Aircraft," recommended by the AIEE Committee on Air Transportation and approved by the AIEE Technical Program Committee for presentation at the AIEE Pacific General Meeting, San Francisco, Calif., August 23–26, 1949. Scheduled for publication in AIEE *Transactions*, volume 68, 1949.

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Low-Power Television Transmitter

L. VOORHEES

The Allen B. Du Mont Laboratories have developed a new television transmitter which propagates low-power signals. Housed in two "dead front" cabinets, the visual transmitter has an output of 500 watts peak. The aural unit, housed in a third cabinet, puts out 250 watts.

THE Du Mont Acorn Series Transmitter Equipment is designed to fulfill the requirements of television stations intended for local coverage and also to be used as the basic unit for a station owner who is desirous of starting out on a small scale and increasing his power output through addition of a 5-kw amplifier. It also makes an ideal stand-by transmitter. To cover all the low- and high-frequency channels, it was necessary to make four different transmitters: high- and low-band aural and high- and low-band visual units. The aural transmitter has a power output of 250 watts, and the visual output is 500 watts peak.

The visual high-band transmitter consists of 13 units (see block diagram, Figure 1). The radio-frequency exciter employs a *6V6* in the oscillator stage with its output tuned to twice the crystal frequency. The next two stages, also using *6V6*'s, are doubler stages. The *829-B* following the second doubler is a straight push-pull stage whose output is used to drive the tripler stage. Metering of these stages is accomplished with a 1-milliampere meter mounted on the front panel of the exciter unit. By means of a selector switch and shunts, the meter is connected in the grid circuit of the first doubler and the oscillator stage is tuned for maximum deflection. Likewise, the output of the first doubler is tuned for maximum grid current in the second doubler stage. The second doubler is tuned for maximum grid current in the *829-B* stage. The plate circuit of the *829-B* is tuned by observing the cathode current of the output stage. Each tuned circuit has a padder capacitor, with a screw driver adjustment on the front panel in parallel with the tuning capacitor so that the output frequency range of the exciter unit is adjustable from 55 to 85 megacycles.

The output of the exciter is link-coupled to the grid circuit of the tripler stage directly above it, employing a pair of *4-65A*'s. The grid tank is a conventional tuned push-pull circuit. The plate tank of the *4-65A*'s is formed by means of tuned half-wave lines. The tubes are located on the one end of the lines and a split-stator capacitor across the opposite end. Plate voltage is fed to these lines through radio-frequency chokes that are positioned on the lines a quarter wave back from the anodes of the tubes, which, of course, is the radio-frequency voltage null point. By means of the split-stator capacitor, the lines are tuned to the third harmonic of the grid circuit which is the carrier frequency, and is tunable from 170 to 220 megacycles. The output of the tripler is link-coupled to the grid circuit of the modulated amplifier, employing a pair of *4X150A*'s in push-pull. The grid and plate tank consist of tuned half-wave lines. The cathodes of the *4X150A*'s are grounded and bias for this stage is obtained from the voltage drop across the plate-load resistor of the modulator stage mounted directly beneath the grid lines. The modulator plate supply is grounded; thus, the plate end of the modulator-load resistor will be at some negative voltage with respect to ground depending on the value of modulator plate current. With no video signal fed in, the modulator grid bias is adjustable so that the modulator plate current will be of such value that voltage drop across the plate-load resistor will permit the *4X150A*'s to operate at projected cutoff for class *B* linear operation. With modulation, the modulated amplifier has a certain d-c value of bias plus a video component whose sync tips are held at a constant level with respect to ground by means of the d-c restorer. The power output of this stage with a fixed amount of radio-frequency drive will vary according to the varying level of bias produced by the modulator plate load. Therefore, the plate circuit will see a modulated radio-frequency signal. From this point on, all tuned circuits must be broad band in order to pass the video-frequency side bands produced by modulation. All tuned circuits from the crystal oscillator to and including the modulated amplifier grid lines are tuned in the conventional narrow band manner. The optimum band-pass characteristics are obtained by overcoupling the succeeding stages. This is accomplished by overcoupling the plate lines of the modulated amplifier and the half-wave grid lines of the *4X500A* final stage. Likewise, the *4X500A* final half-wave plate lines are overcoupled to the output circuit. Varying the amount of coupling of these two overcoupled stages is accomplished by means of a sliding plate which traverses between the half-wave lines and the output circuit.

To obtain the optimum band-pass characteristic of the afore-mentioned two overcoupled circuits, two additional units are incorporated in the transmitter which are used only for setting the band pass of these two circuits. One is a radio-frequency wobbulator using a pair of *826*'s whose output frequency is adjusted to deviate approximately four megacycles above and below the carrier frequency. The frequency swing is accomplished by a 1,800-rpm synchronous motor driving a butterfly capacitor which varies the frequency of the wobbulator plate tank.

Essentially full text of paper **49-257**, "A 500-Watt Visual 250-Watt Aural Television Transmitter," recommended by the AIEE Communication Committee and approved by the AIEE Technical Program Committee for presentation at the AIEE Fall General Meeting, Cincinnati, Ohio, October 17–21, 1949. Not scheduled for publication in AIEE *Transactions*.

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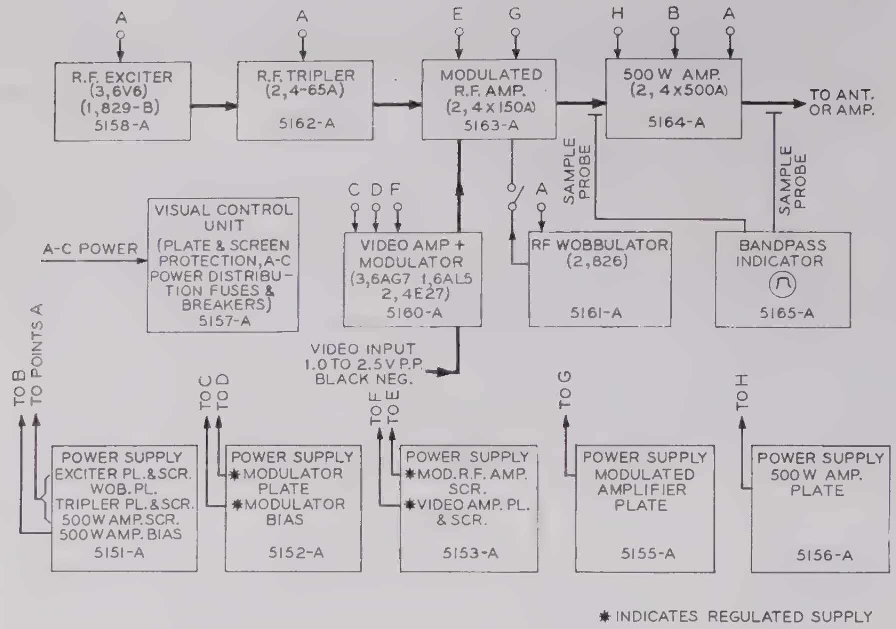


Figure 1. Block diagram of visual high-band transmitter

The output of the radio-frequency wobbulator is fed through a terminated coaxial line to the half-wave grid lines of the modulated amplifier by means of a double-pole relay which is energized when the wobbulator is turned on.

The other unit is a band-pass indicator which employs a 5-inch cathode-ray tube. A sample of radio-frequency voltage is taken from each overcoupled circuit, detected, and fed into the vertical plates through an amplifier for each signal, which is alternately gated by applying a 60-cycle voltage to the suppressor grids. By means of this switch action, two traces appear on the tube, one for each circuit. As the wobbulator sweep varies at a synchronous rate, a 60-cycle voltage is used for horizontal sweep.

Broad-banding the last two stages becomes a simple procedure with the built-in wobbulator and band-pass indicator. By turning the switch on the wobbulator to the "wobbulate" position, a signal is fed to the grid lines of the modulated amplifier. Since it is required that the lower side-band be attenuated, both stages are tuned to favor the upper side-band. Markers (that is, a zero beat between the wobbulator signal and the carrier frequency from the tripler) will appear on the band-pass pattern. By turning the crystal selector switch on the exciter unit to the marker crystal, another marker will appear on the trace three megacycles higher. By varying the tuning of the modulated amplifier plate lines and the *4X500A* grid lines, the two markers are adjusted for equal amplitude. By varying the degree of coupling by means of the sliding plates between the two circuits, the band pass can be varied so that the markers will appear on the flat-top portion of the response curve at the point where band pass starts to cut off. Tuning the second overcoupled circuits (that is, the *4X500A* plate lines and the output tank which feeds the transmission line) is done in the same manner.

The aural high-band transmitter consists of eight units, Figure 2. The frequency-modulation exciter employs a conventional Hartley oscillator circuit whose frequency can be varied by two reactance tubes. One of these reactance tubes is used to insert the audio-frequency modulation, and the other tube is used to control the center frequency of the oscillator. The output of the oscillator feeds a frequency tripler which in turn drives a frequency doubler. The output of the doubler stage is link-coupled to the frequency-modulation driver unit. The output of the oscillator is also fed into a frequency-dividing network and divides the frequency down to one-fifth of the oscillator frequency which is the discriminator frequency. A crystal is selected whose impedance, at a point half-way between its series and parallel resonance, is equal to a reference impedance. The voltages developed across the crystal and reference impedances are rectified separately and added in opposite polarity, which produces a d-c output voltage which is the arithmetic difference between the two direct voltages produced by the rectifiers. This voltage controls the reactance tube which determines the center frequency.

The frequency-modulation driver is identical to the visual exciter, except for the first *6V6* which is used as a straight doubler receiving its drive from the frequency-modulation exciter, while in the visual exciter it is a crystal doubler.

The radio-frequency tripler is also essentially the same as the tripler used in the visual transmitter. Due to its location with respect to the *4X500A* final stage, which it drives, direct coupling is used and the amount of drive is controlled by a sliding plate arrangement.

The 250-watt final stage employs half-wave tuned lines in both the grid and plate circuits. A pair of *4X500A*'s are used in this stage. Power is coupled out of this stage into the transmission line with an adjustable hairpin loop.

Each transmitter has a control unit which has many unique features. In the aural transmitter, this unit con-

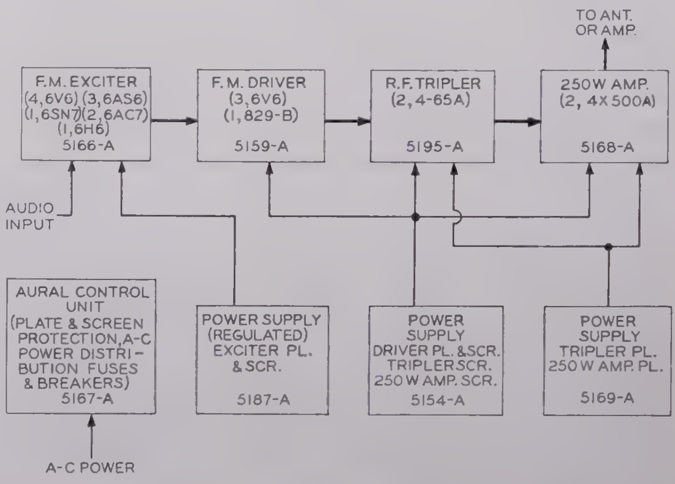


Figure 2. Block diagram of aural high-band transmitter

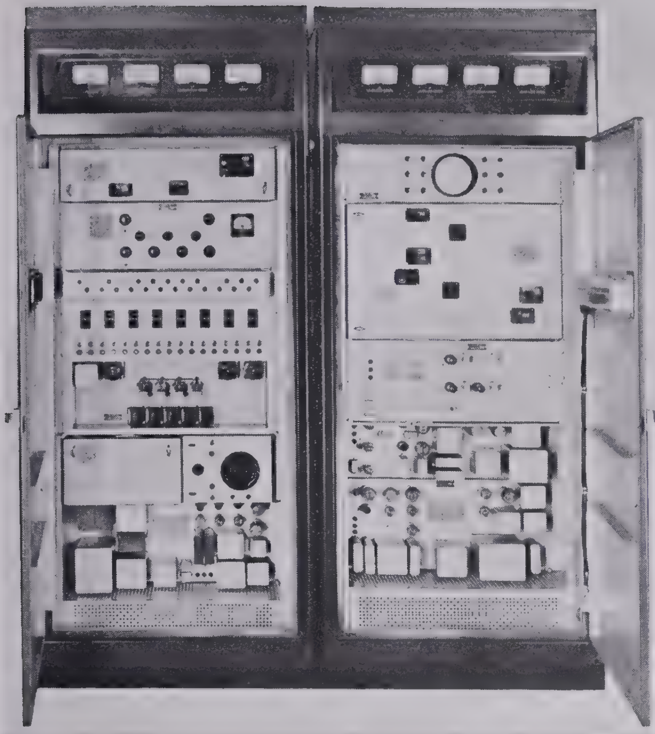


Figure 3 (left). Visual cabinets

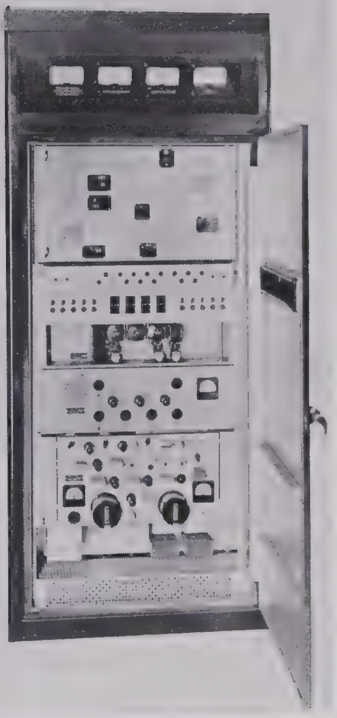


Figure 4 (right). Aural cabinet

tains all the circuit breakers, overload relays, time-delay relays, and fuses. A built-out section on this unit which projects to the cut-out in the front door has the start, plate, reset, and high-low power switches mounted on it, and all the indicator lamps. The lighting sequence of these lamps is from left to right. When the transmitter is turned on, each light comes on in turn until a circuit appears that is not normal. The failure of the light is an immediate clue as to the nature of the trouble, and when the circuit is restored to normal, that light will light, and each one thereafter until all lights are on. In the event a circuit associated with one of the lights fails, all lights to the right of the offending circuit will be extinguished. Circuit breakers on the primary of the power supplies are so interlocked that power for a screen supply cannot be applied until the plate supply circuit breaker is closed.

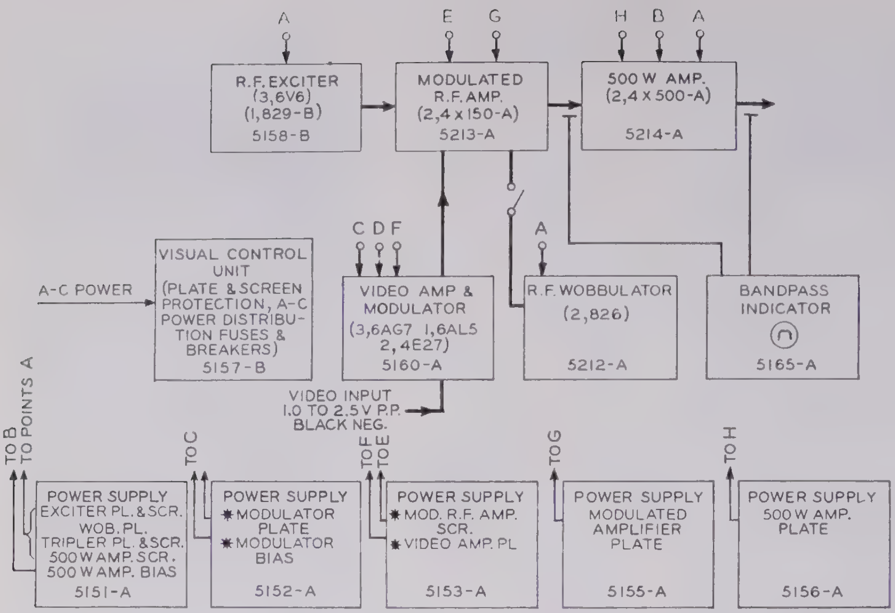
Another unusual feature is the "memory circuit" which operates in the event a momentary overload occurs; operating voltages are removed, and after two seconds are restored. If the overload condition is no longer present, the transmitter will resume normal operation. In the event the overload is a permanent one, the aural transmitter will recycle three times and then drop back to low power. If the overload is present on low power, the transmitter will recycle twice and then go off the air. The indicator lamp in the memory circuit associated with the overload will go out and stay out regardless of whether the overload was momentary or one of a permanent nature. To restore the light in the event of a momentary overload or to put the transmitter back in operation after it has recycled five times, a reset switch is operated. Each transmitter is equipped with a single-stroke bell that is energized each time the transmitter recycles.

In the visual transmitter, the control unit is located in the exciter cabinet. The start, plate, and reset switches are located on a control box in the cut-out of the visual final cabinet door. The visual control unit differs only in the recycling. It does not put the transmitter on low power after the third recycle; it continues to the fifth recycle in the event of a permanent overload, and then shuts the transmitter off.

The transmitters are housed in three cabinets. Considerable time was given to the mechanical design of the cabinets and the mounting of the chassis in the cabinets (see Figures 3 and 4). The transmitters are a "dead front" design, that is, no operating voltages are present with the main front doors open. All tuning controls, adjustable potentiometers, and test jacks are accessible with the main doors open. Interlocks and short-circuiting devices on all back and secondary doors prevent accidental contact with high voltage.

Cooling of the cabinets is accomplished by fans located on the inside of each rear door which draw air in through a filter at the bottom of the cabinet and exhaust it out the top. In the visual final cabinet, the modulated amplifier stage, using a pair of *4X150A*'s and the final stage employing a pair of *4X500A*'s each have blowers mounted in the top of the cabinet for exhausting the air through ducts from the anodes of the tubes. A small blower is also mounted on the back of the *4X500A* chassis to maintain low seal temperatures on the base of the tubes. In the aural cabinet, one blower is located in the top of the cabinet for exhausting the air from *4X500A* final anodes in the same manner that it is accomplished in the visual cabinet. Two additional small blowers are used: one on the back of the *4X500A* chassis; and the other is mounted between the upright channels of the cabinet to maintain low seal temperatures on the *4X500A*'s and the *4-65A*'s used as triplers.

One of the mechanical features of the transmitter is the manner in which all units, with the exception of the high-voltage power supplies which are mounted in the base of the cabinets, are rack-mounted. All the chassis are so designed that they are self-contained, and each one individually mounts on $29^1/_2$-inch centers. To install or remove any unit, no other chassis has to be disturbed. All


A
E G
H B A
R.F. EXCITER (3,6V6) (1,829-B) 5158-B
MODULATED R.F. AMP. (2,4x150-A) 5213-A
500 W AMP. (2,4 x 500-A) 5214-A
C D F
A
VISUAL CONTROL UNIT (PLATE & SCREEN PROTECTION, A-C POWER DISTRIBUTION FUSES & BREAKERS) 5157-B
A-C POWER
VIDEO AMP & MODULATOR (3,6AG7 1,6AL5 2,4E27) 5160-A
R.F. WOBBULATOR (2,826) 5212-A
BANDPASS INDICATOR 5165-A
VIDEO INPUT 1.0 TO 2.5 V P.P. BLACK NEG.
TO B
TO POINTS A
TO C
TO F
TO E
TO G
TO H
POWER SUPPLY EXCITER PL. & SCR. WOB. PL. TRIPLER PL. & SCR. 500 W AMP. SCR. 500 W AMP. BIAS 5151-A
POWER SUPPLY ✱MODULATOR PLATE ✱MODULATOR BIAS 5152-A
POWER SUPPLY ✱MOD. R.F. AMP. SCR. ✱VIDEO AMP. PL 5153-A
POWER SUPPLY MODULATED AMPLIFIER PLATE 5155-A
POWER SUPPLY 500 W AMP. PLATE 5156-A

✱ INDICATES REGULATED SUPPLY

Figure 5. **Block diagram of visual low-band transmitter**

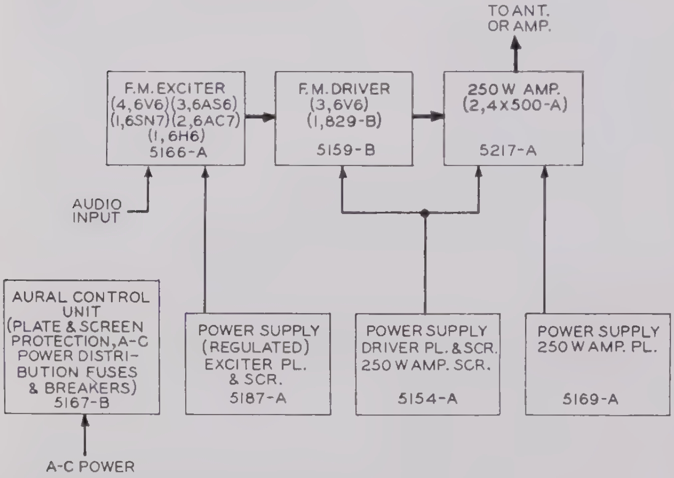

TO ANT. OR AMP.
F.M. EXCITER (4,6V6)(3,6AS6) (1,6SN7)(2,6AC7) (1,6H6) 5166-A
F.M. DRIVER (3,6V6) (1,829-B) 5159-B
250 W AMP. (2,4x500-A) 5217-A
AUDIO INPUT
AURAL CONTROL UNIT (PLATE & SCREEN PROTECTION, A-C POWER DISTRIBUTION FUSES & BREAKERS) 5167-B
POWER SUPPLY (REGULATED) EXCITER PL. & SCR. 5187-A
POWER SUPPLY DRIVER PL. & SCR. 250 W AMP. SCR. 5154-A
POWER SUPPLY 250 W AMP. PL. 5169-A
A-C POWER

Figure 6. **Block diagram of aural low-band transmitter**

tuning controls are mounted on their associated chassis.

Metering of all stages beyond the frequency-modulation driver and visual exciter is accomplished with four meters mounted above the front doors of each cabinet.

For low-band installations, the aural and visual transmitters are housed in the same type of cabinets. By choice of crystals and the number of multiplying stages, the output frequency range of the aural driver and visual exciter are in the low band, channel 2–6 range (block diagrams, Figures 5 and 6). Therefore, it is only necessary to eliminate the *4-65A* tripler stage in each transmitter and use the aural driver output to drive the *4X500A* final in the aural transmitter and the visual exciter output to drive the *4X150A* modulated amplifier in the visual transmitter.

The half-wave lines in the aural final, the visual modulated amplifier, the visual final, and the radio-frequency wobbulator are replaced with conventional lump inductance tank circuits. Other than the afore-mentioned changes, the operation and performance of the low-band television stations are the same as the high-band installations. Two auxiliary cabinets, which house monitoring and switching facilities, are furnished as part of the transmitter.

Directly above the shelf of the left cabinet is mounted a video switching unit which, by means of five push buttons, allows any one of five incoming video lines to be fed into a line amplifier. Underneath these five line selectors are five more push buttons that enable the operator to preview the incoming signals. Three monitors are mounted in the top half of this cabinet. Two of them are wave-form monitors employing a 5-inch cathode-ray tube. One is used for viewing the signal at line rate, and the other at frame rate. The third monitor is a picture monitor with a 12-inch cathode-ray tube.

The output of the line selector is connected to a line amplifier, and its output is fed to the input of the video modulator in the visual transmitter. The output of the line amplifier is adjustable by means of a transmitter input level control mounted in the center of the panel. On the right side of the panel are two rows of push buttons, the top row for switching in the two wave-form monitors, and the bottom row for switching in the picture monitor. By means of these push buttons, the following can be viewed: line amplifier input, preview transmitter input, three points within the visual transmitter, and the transmission line.

Above the video switching unit, the aural switching unit is mounted. It has a double row of five push buttons for selecting any one of five incoming aural lines. The top row switches the incoming signal into the aural transmitter, and the bottom row enables the operator to monitor any one of the incoming lines. Four more push buttons are located above the incoming line selector, which enables the operator to monitor line input, off-the-air receiver, frequency monitor output, and transmitter input. Two attenuators are mounted in the middle of the panel for controlling the input to the aural transmitter. On the right side of the panel is a meter for indicating input level to the transmitter.

A visual-frequency monitor is mounted in the top of the cabinet for indicating center frequency deviation of the visual transmitter. In the top half of the right-hand cabinet, the aural frequency monitor is mounted. This equipment is mounted on two chassis. The top unit has two meters, one for indicating center frequency deviation, and the other percentage of modulation. A flasher circuit is used to indicate "overmodulation." The power supply is mounted on the second chassis directly beneath the monitoring equipment. All equipment mounted in these two cabinets, with the exception of the crystal heaters in the two frequency monitors, receive their power through a central switching unit mounted in center of the right-hand cabinet. All units are controlled from this panel.

An Analysis of Relay Servomechanisms

D. A. KAHN
MEMBER AIEE

THE METHODS of analysis and synthesis of linear servomechanism loops have been developed to the point where they have become a common and useful tool. Comparable advances have not been made in the case of relay-type control although the latter is of great importance in many engineering fields. The reason for this failure is that the differential equations governing a relay-controlled system are nonlinear in nature and cannot be solved by conventional means. Nevertheless, it is possible to analyze such a system by accepting something less than a finite analytic expression for the solution of the governing differential equation. Application of Laplace transform theory to this problem yields the response expressed as a series of terms from which the system behavior may be found. The information obtainable in this manner indicates whether the system under consideration is stable or unstable and gives relations among the circuit parameters which must hold if the response of the system is periodic. This method is not restricted to cases of intermittently applied constant torque as in previous treatments but is applicable to any controlled object whose unilateral transfer function can be written, as for example a motor, a vacuum-tube circuit, or a complete servomechanism loop.

The differential equation of a simple relay servomechanism loop may be written as

$$Z(p)y(t)=\Gamma(x-y) \tag{1}$$

where

$p=\dfrac{d}{dt}$

$Z(p)$ = a polynomial in p

x = the input signal

y = the system response

$$\Gamma(x-y)=\begin{cases}+E \text{ when } (x-y)>\epsilon\\ 0 \text{ when } -\epsilon<(x-y)<+\epsilon\\ -E \text{ when } (x-y)<-\epsilon\end{cases}$$

E = the (constant) relay output, either voltage or current

ϵ = the minimum error required to operate the relay

When operated on by the unilateral Laplace transform, equation 1 becomes

$$Y(s)=\frac{E}{sZ(s)}(1-e^{-t_1s}-e^{-t_2s}+e^{-t_3s}+e^{-t_4s}-\ldots)+I(s) \tag{2}$$

where

$Y(s)=\mathcal{L}[y(t)]$

$I(s)$ contains the system initial conditions

$t_1, t_2, t_3, \ldots$ are roots of $x(t)-y(t)=\pm\epsilon$

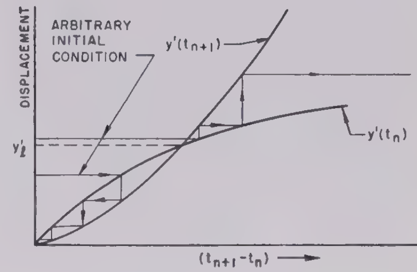


Figure 1. A typical semistable response

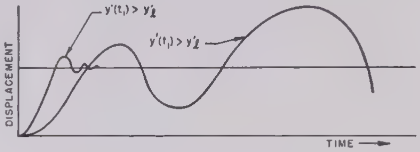


Figure 2. Illustration of the information obtainable from curves similar to Figure 1

In the time plane equation 2 becomes

$$y(t)=\eta(t)-\eta(t-t_1)u(t-t_1)-\eta(t-t_2)u(t-t_2)+\eta(t-t_3)u(t-t_3)+\ldots \tag{3}$$

where

$$\eta(t)=\mathcal{L}^{-1}\left[\frac{E}{sZ(s)}\right]$$

$$u(t)=\begin{cases}0 & t<0\\ 1 & t\geq 0\end{cases}$$

Equation 3 states that the response of a relay servomechanism can be expressed as a series of like terms disposed along the time axis in a manner dependent on the as yet unknown roots of $x-y=\pm\epsilon$. By operating on equation 3, curves of the nature of Figure 1 are obtainable.

For $t<t_1$, an analytic expression for $y(t)$ is available since by equation 3

$$y(t)\equiv\eta(t) \qquad 0\leq t\leq t_1 \tag{4}$$

In addition to the information obtainable from equation 4, there is available from Figure 1 the value of the derivative at each root of $x-y=\pm\epsilon$ as well as the intervals between succeeding roots. This information is sufficient to plot qualitatively the curves of Figure 2. In Figure 2, $y_1(t)$ represents the response of a system similar to that of Figure 1 for a value of $y'(t_1)$ greater than y_e'. Similarly, $y_2(t)$ represents the response of the same system corresponding to a value of $y'(t_1)$ less than y_e'. This clearly shows that stability depends in part upon assumed initial conditions.

Equation 3 can also be made to yield relations among the system parameters which must hold when the system oscillates periodically.

The method can be successfully applied, for example, to a system characterized simultaneously by moment of inertia, velocity friction, coulomb friction, a relay time delay on "make" and "break," and some minimum error ϵ required to operate the relay.

Digest of paper **49-224,** "An Analysis of Relay Servomechanisms," recommended by the AIEE Joint Subcommittee on Servomechanisms and approved by the AIEE Technical Program Committee for presentation at the AIEE Pacific General Meeting San Francisco, Calif., August 23–26, 1949. Scheduled for publication in AIEE *Transactions*, volume 68, 1949.

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Lightweight Aircraft Transformers

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THE LARGE a-c electric loads and voltages of airplanes provide such applications for transformers as lighting, instrumentation, control, rectification, and window deicing. Transformer size and weight are determined by the quality of magnetic circuit and temperature limits of the insulation, the a-c frequency being fixed by the aircraft generators. As a transformer designed for a given load is made smaller, the iron and copper must be worked harder; and thus, increased losses and high operating temperatures are the prices to be paid for size reduction.

The coil insulating materials are chosen to withstand an average temperature rise of 200 degrees centigrade at a 25-degree centigrade ambient temperature. Insulating materials are glass tape, flexible mica, and silicone-impregnated fiberglass. Voltages seldom exceed 500 volts, and relatively little insulation is required. The result is a rigid coil which gives good transfer of heat. Flexible leads are brazed to the wire of the coil and are insulated with silicon-impregnated glass tubing. The cores are assembled around the coil sides and the assembly is vacuum impregnated with silicone varnish. Silicone varnish is "tacky," and becomes neither brittle nor fluid over the wide temperature ranges encountered.

It should be noted how the temperature rise of a transformer is affected by altitude. The heat transmitted by conduction is a function of the mounting surface contact area, the temperature difference between frame and surface, and the thermal conductivity of adjoining materials. Radiation loss is proportional to the fourth power of the absolute temperature and the area. Cooling by convection is a function of the air density and, hence, decreases rapidly with altitude. At high altitude, the temperature rise increase is such as to offset the decrease in convection cooling by increased conduction and radiation. Transformers designed for a minimum convection cooling have the least increase in temperature rise when subjected to altitude condition.

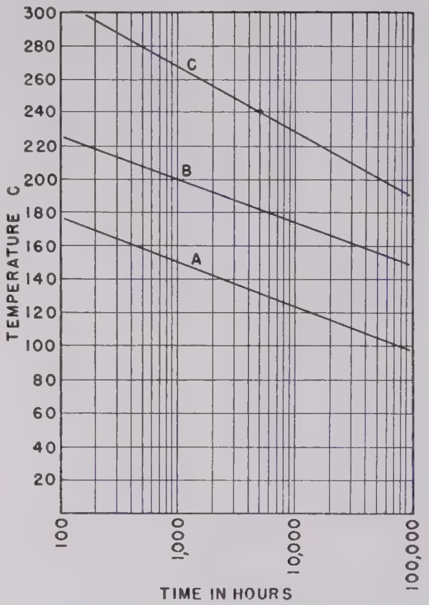

Figure 2. Estimated life of transformer
Curve A—Class A insulation
Curve B—Class B insulation, varnish treatment, ten per cent duty cycle
Curve C—Silicone insulation and silicone impregnation

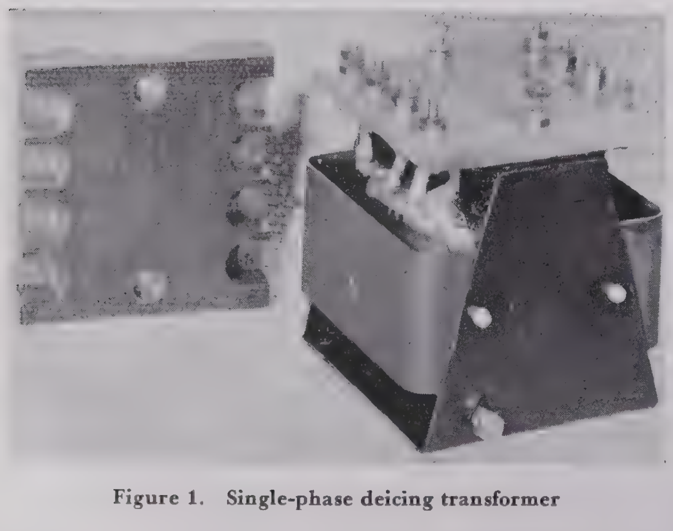

Figure 1. Single-phase deicing transformer

The construction of a deicing transformer, which is typical of other aircraft transformers, is illustrated by Figure 1. The coil has relatively little area exposed and dissipates heat loss by radiation, convection, and conduction to the core. The inside of the coil has the highest temperature rise of any part, and the rise is less for the coil surface, core surface, and frame in the order named. The mechanical parts must be rigid to stand up under vibration.

The life of a transformer depends upon the life of its insulation because it is a static device and not subject to wear or mechanical failure. Deterioration of insulation is a function of temperature, and operating temperature may be used to predict life. Very little data are available which are based on actual life tests on aircraft transformers, and a comparison method must be used to estimate life. The electrical industry has accumulated much data on the life of class *A* insulation (organic materials) which can be accepted as valid. The life of class *A* insulation is shown by curve *A* of Figure 2. Curve *B* shows the life of class *B* insulation (inorganic materials) with the usual varnish impregnation. Curve *B* is based on a ten per cent duty cycle but meager data exist for its proof. Curve *C* of Figure 2 illustrates the life of silicone insulation (includes mica) impregnated with silicone varnish. Curve *C* is based on tests made on electric motors operating continuously and should apply equally well to transformers. It is reasonable to expect a continuous duty life of 2,000 to 5,000 hours for a high-temperature aircraft transformer.

Digest of paper **49-223**, "Lightweight Aircraft Transformers," recommended by the AIEE Committee on Air Transportation and approved by the AIEE Technical Program Committee for presentation at the AIEE Pacific General Meeting, San Francisco, Calif., August 23–26, 1949. Scheduled for publication in AIEE *Transactions*, volume 68, 1949.

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The Eccentric Pole Face

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PREDICTING commutation is not an exact science, and no one factor will tell the designer whether or not the design will commutate satisfactorily. Many factors, such as reactance voltage, commutating pole dimensions, neutral or clearance zones, magnetic densities, and volts per bar must be considered simultaneously, and, in the end, experience and judgment must be exercised in interpreting the design calculations.

On adjustable-speed motors the strong cross magnetization at weak field causes high volts per bar at the leading main pole tips. This is one of the most important considerations in the design of adjustable speed motors. The flux distribution and volts per bar across the main pole arc are easily calculated at weak field strength and can be checked by test at both no load and full load. Experience has shown that if the volts per bar at the leading tip are limited to approximately 30 and adequate neutral or clearance zone is provided, satisfactory commutation and speed regulation can be obtained. Formulas for calculating the flux distribution clearly indicate means of minimizing the tip volts per bar and thus improving motor performance. Tip volts per bar can be materially reduced by chamfering the main pole tips, but this has the disadvantage of concentrating the flux at the point where the chamfer starts, causing high volts per bar at this point. This may cause flashover if the volts per bar are high enough. An eccentric pole face with a constant radius, much greater than the air gap radius, gives a gradually flaring air gap that eliminates the sharp concentration of flux caused by the chamfer and is therefore preferable. While no optimum ratio of maximum to minimum gap can be derived, a study of several different pole arc shapes indicates that a pole face radius which gives a tip gap of four times the center gap, or a four-to-one flare, is an excellent compromise for adjustable speed motors of this type.

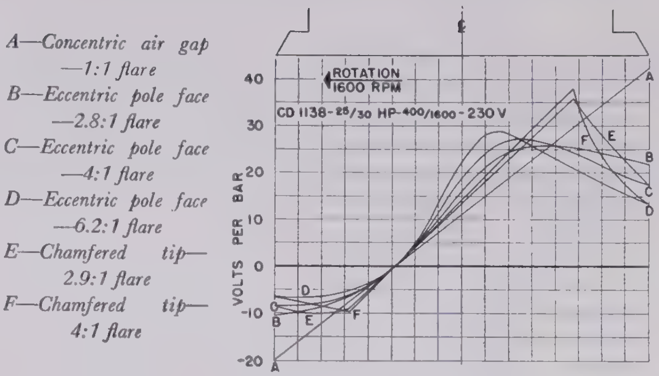

Figure 2. Effect of pole arc shape on unsaturated flux distribution at full load

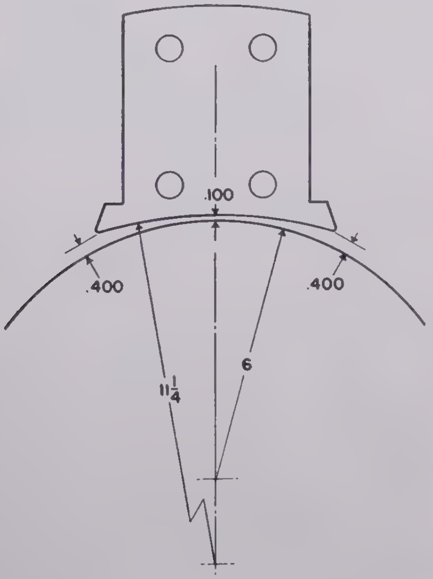

Figure 1. Typical eccentric pole face

On constant speed motors and generators where the armature teeth are well saturated the flux tends to distribute itself uniformly in spite of the varying air gap. However, the high reluctance which the eccentric pole face offers the armature cross flux improves the performance of these machines also. The four-to-one flaring air gap concentrates the flux under the center of the main pole at light loads and thus increases the stability of self-excited generators and exciters.

In an attempt to evaluate several different shapes of main pole arcs, the flux distribution or volt per bar curve was calculated for several assumed pole arc shapes for a standard 25/30-horsepower 400/1,600-rpm 230-volt motor. Calculations were made for 1,600 rpm and full load. These calculated data are plotted in Figure 2. The air gap data for these curves are shown in Table I.

Table I. Air Gap Data for Different Shape Pole Faces

Curve	Type	Flare	Air Gap (Inches) Minimum	Maximum	Average
A	Concentric gap	1:1	0.130	0.130	0.130
B	Eccentric pole face	2.8:1	0.090	0.250	0.130
C	Eccentric pole face	4:1	0.078	0.312	0.130
D	Eccentric pole face	6.2:1	0.066	0.408	0.130
E	Chamfered tip	2.9:1	0.108	0.312	0.130
F	Chamfered tip	4:1	0.102	0.408	0.130

Since the eccentric pole face concentrates the flux under the center of the pole it tends to increase the no-load core loss. This is partially offset by reduced load loss and presents no serious problem on adjustable speed motors. However, on constant speed motors and generators which have a higher base speed, heating may be increased if the ratio of tip to center gap is too great.

Digest of paper **49-230**, "The Eccentric Pole Face—A Means to Better D-C Machine Performance," recommended by the AIEE Committee on Rotating Machinery and approved by the AIEE Technical Program Committee for presentation at the AIEE Fall General Meeting, Cincinnati, Ohio, October 17–21, 1949. Scheduled for publication in AIEE *Transactions*, volume 68, 1949.

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Use of the Relay Digital Computer

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Modern digital computers are capable of great flexibility. They can be applied to a wide range of problems from the simplest to the most abstruse. This is a description of some of the problems solved successfully by the Bell Laboratories Model V computer.

TWO LARGE-SCALE general-purpose digital relay computers designated Model V have been constructed for the National Advisory Council for Aeronautics at Langley Field, Va., and for the Ballistic Research Laboratories at the United States Army Ordnance Station at Aberdeen, Md. They are characterized as being controlled by perforations on teletype tapes and using the relays and design technique of dial telephone systems.

The various tapes required for a problem are originally perforated on a manually operated machine having a keyboard resembling that of a typewriter. They are then processed into a code suitable for the computer. The number of tapes required for a problem varies from 2 to 12 depending upon its complexity. As soon as all the tapes for a problem have been processed, they are loaded into one of four problem position tables. As the answers are worked out they are printed on one of the two recorder tables. Part of the equipment performing the computing is shown in Figure 1. It consists of about 9,000 telephone relays mounted on 27 frames. A motor generator and storage battery are furnished for the 50-volt d-c supply. This relay equipment constitutes two independent computers. They obtain the information for problems from two of the four problem positions. Connections between these components are made automatically. Since four problem positions are furnished, two additional problems may be loaded while two others are being solved, making it possible to overlap the problem setup time completely.

The general appearance of a tape is shown in Figure 2. The code for a character consists of some combination of six holes on vertical centers.

Figure 3 shows a problem position with a short problem tape in the tape transmitter on the extreme right and a routine tape in the next position. The simplicity of operation of this part of the equipment is attested to by the fact that a card 5 by 8 inches with 5 to 15 entries contains all of the required information for setting up a problem.

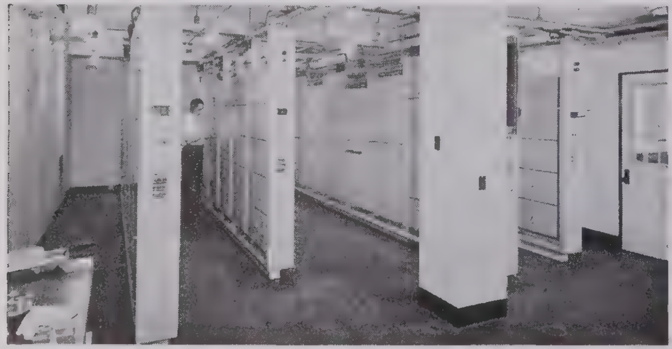

Figure 1. Equipment room components of Ballistic Research Laboratory installation

The actual loading operations for a problem with a maximum of 12 tapes may take as much as five minutes. A small key panel provides facilities for momentarily stopping or completely disconnecting the problem at the problem position.

STOPPAGES

Visitors often ask, "What happens when something goes wrong?" The answer is simple; the computer stops. In all but a few kinds of troubles it stops at the instant of failure. In no case will operations continue to the point where a wrong solution is given. A design has thus been obtained which produces answers which are to all practical purposes 100 per cent correct. A summary of the records kept during the trial period shows that the average time required to diagnose and correct causes of stoppage was under 15 minutes. The maximum was two hours. In one week at the Ballistic Research Laboratory, Aberdeen, Md., one computer was in operation for 167 hours out of a possible 168, and the other was in operation 165 hours.

The lamp indicator panel shown in Figure 4 indicates the progress of operations in the computer. Some causes of stoppage, such as when an attempt is made to take the square root of a negative number, are indicated directly on the lamps in the lower left panel. Other stoppages require analysis using the other lamps. The three vertical rows of push-button keys on the right enable the personnel to insert numbers and computing instructions manually.

The preceding description of the physical aspects of the computer has been quite general, but if one gets closer to the machine, he finds that it has a number of well-defined and familiar components. They are shown in block-diagram form in the right half of Figure 5. The diagram in the left half shows the facilities which are available to a manual computer organization.

The discriminator in the right-hand diagram is the only box about which any comment need be made. The counterpart of this in the manual setup is the box designated "Decisions." The human computer may interpret a change in the trend of the problem as an indication of the need of using another formula, the need of referring the situation to the mathematician in charge, or as an indica-

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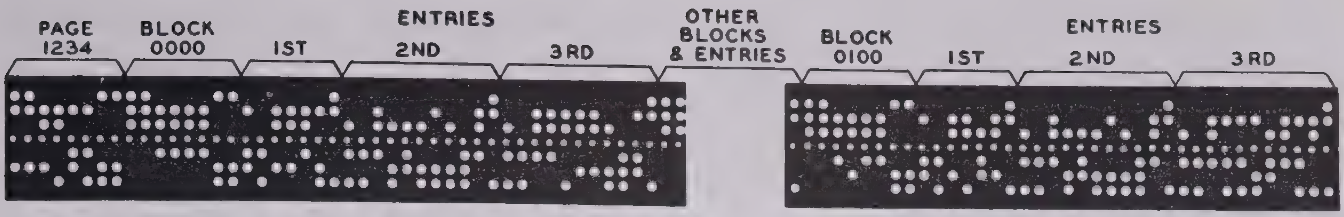

Figure 2. Typical tape used in the Model V computer

tion that computations have progressed far enough. Similarly, the Bell Laboratories Model V computer may be instructed beforehand to examine intermediate results and take one of several kinds of action. It may choose between any one of several formulas; it may sound an alarm for the attendant, or it may proceed to the next step without taking any new action.

Use of the computer for simple problems is inefficient because the problem can be worked manually faster than it can be inserted into the computer. In order to handle a problem efficiently on any of today's large-scale computers it must embody repetitiveness; that is, the problem must consist of subdivisions of instructions, all or some of which are reused many times.

To show the method of handling an actual typical problem on the computer would require a lengthy explanation. Instead, a simple problem which makes use of only a small amount of the computer's potentialities will be used. It is to code the tapes necessary to enable the computer to find the roots of a large number of quadratic equations. The usual form for the original equation and the usual formula for the roots are

$$ax^2+bx+c=0 \tag{1}$$

$$x_1, x_2=\frac{-b\pm\sqrt{b^2-4ac}}{2a} \tag{2}$$

The urge to proceed with the coding of the problem is almost overpowering, but it is wiser first to give some consideration to other forms and formulas. For example, it may be advantageous to use the following equations instead of equation *2*.

$$x_1=\frac{-b+\sqrt{b^2-4ac}}{2a} \tag{3}$$

$$x_2=-\frac{b}{a}-x_1 \tag{4}$$

Consideration should also be given to the following forms:

$$ax^2+2bx+c=0 \tag{5}$$

$$x_1, x_2=\frac{-b\pm\sqrt{b^2-ac}}{a} \tag{6}$$

The computer has its own personality. It has a preferred manner in which it solves the problem and it is a prime requisite in obtaining an answer quickly for the problem composer to select the one which the machine prefers. Without attempting to give the details of why any one of the formulas is superior to any other, let it be decided to use equations 1 and 2. Even with this decision made, it is wise to study equation 1 carefully, for an inspection shows that equation 2 is not valid when the a is zero. Also possible imaginary roots must be dealt with.

The next consideration is to plan the form in which answers are to be printed. The minimum would call for printing only the computed values of x_1 and x_2. The maximum would call for all of the intermediate values that are calculated as well. It will be decided arbitrarily to print the three coefficients and the two roots. The appropriate column heading information then is entered on the form which records the problem tape data. Also, it is entirely practicable to list any other desired information such as sources of information, dates, or references.

It is now time to proceed with detailed instructions for the computing on the basis that the coefficients a, b, and c are on the problem tape, although the sequence in which they appear is yet to be determined.

It is best that the a be introduced first because it is the indicator to be used for choosing another formula in case its value is zero. For reasons which will later become apparent the c is introduced as the second number and the b as the last. A slightly abridged form of the routine tape instructions for computing makes use of the following codes and symbols.

J denotes storing register *J*
K denotes storing register *K*
L denotes storing register *L*
S denotes register which reads problem tape numbers
PS denotes that discrimination must be made
QP denotes that number should be printed
c denotes that register should release as soon as number is read out
r denotes that the sign of the number should be reversed
$+, -, \times, \div\ \sqrt{\ }$ denotes arithmetic operations
$\equiv$ denotes a transfer operation

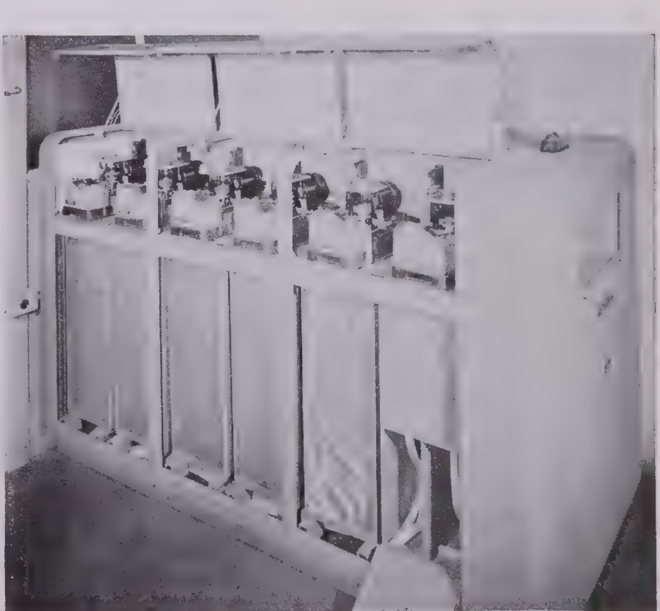

Figure 3. Problem position with covers removed

The first operation of the computer is to carry out the initial instructions on the problem tape. This consists of printing the general information and the column headings and transferring the first problem data number to the problem register. From this point the computer obtains its instructions from the routine tape which might be coded as in Table I.

Table I. Routine Tape Instructions

No.	Instruction on Tape	Explanation
1	$S \equiv PS$	Choose proper formula
2	$S \equiv QP$	Print *a* coefficient
3	$S+S_c=J$	Compute 2*a* and store in
4	$J \times S=K$	Compute 2*ac* and store in
5	$S_c \equiv L$	Store *c* for use on order ?
6	$S \equiv QP$	Print *b* coefficient
7	$K+K_c=K$	Compute 4*ac* and storei
8	$L_c \equiv QP$	Print *c* coefficient
9	$S \times S=L$	Compute b^2 and store in *L*
10	$L_c-K_c=K$	Compute (b^2-4ac) and store in
11	$K_c\sqrt{\ }=K$	Compute $\sqrt{b^2-4ac}$ and store in *K*
12	$K-S=L$	Compute $(-b+\sqrt{b^2-4ac})$ and store in *L*
13	$L_c \div J=QP$	Compute x_1 and print
14	$K_{rc}-S_c=L$	Compute $(-b-\sqrt{b^2-4ac})$ and store in *L*
15	$L_c \div J_c=QP$	Compute x_2 and print
16	Start of the instructions for computing $x=-\frac{c}{b}$	

Instruction *1* makes use of the *a* coefficient in the discriminating order $S \equiv PS$, which instructs the computer to transfer the *a* in the problem register to the discrimination component or the computer without involving any calculation. If the coefficient is zero, the instructions starting with instruction *16* should be employed. If the coefficient is not zero, instruction *2* is used.

Instruction *3* provides for computing the value of the denominator and placing the result in the *J* storing register. Since there is no further need for the *a*, this instruction includes the subscript *c* after the second *S* to provide for clearing out the number in the problem register, thus permitting the *c* to be registered. The other instructions are interpreted in the same manner.

Instruction *11* provides for obtaining the square root of (b^2-4ac). If this quantity is negative an alarm is given automatically at this time which fulfills a discrimination regarding possible imaginary roots as was arbitrarily assumed. If it had been decided to compute imaginary roots, this instruction would call for the absolute value of (b^2-4ac) and a record kept of the true sign of the number.

Instruction *15* provides for computing and printing the second root. A subscript (not shown) is added to *15* to denote that all computing has been completed with one set of problem coefficients and that the computer should proceed with the next set of coefficients on the problem tape using the same set of instructions.

In undertaking a more practical problem the tape composer would give thorough consideration to each of the several possible methods of attack. Since the computer has so much flexibility it follows that the resourcefulness of the problem composer will contribute most to this efficient operation, and this resourcefulness does not stop at making the computer produce the correct answers. It also contributes to an elegant and pleasing page format and to ease of operating. The instructions for printing answers for a long problem can provide for a page format that inserts page numbers and column headings at prescribed places, and a distinctive mark can be printed to locate the place where the long roll of paper upon which the answers are printed should be cut to form pages.

In comparing tape composing with the use of modern desk calculating machines, the computers expressed a strong preference for tape composing assignments because their time was spent coping with the new challenges in a problem rather than the repetitious routine required to obtain its solution. During a 5-month trial period various types of Bell Laboratories' problems were presented to the computer. In some cases problems were repeated using different methods of attack in order to determine which methods were best adapted to machine operation.

The practical range of application of the Model V computer is determined by operating considerations. The machine is equipped with controls which enable it, in theory, to do any job of computing which one might expect a human computer to do by pencil and paper using an ordinary desk calculating machine. One would naturally expect that the machine might be too slow or too cumbersome to be an effective tool for some types of problems, and it is this aspect of the situation which the program of trial problems was particularly intended to examine.

ARRANGEMENT OF COMPUTATION

Many of the operating characteristics of the Model V computer depend upon the way in which computations are arranged for the machine. This can be discussed most conveniently by comparison with the way in which problems are usually arranged for human computers or for computation using the well-known International Business Machine accounting equipment. Human computers very commonly employ a work sheet in which the successive columns represent the successive stages in an individual computation, while the successive rows represent independent cases of the given problem. It is more efficient for human computers to perform a given operation repeatedly than it is to shift constantly from one elementary mathematical operation to another. They tend to favor a column-by-column attack. This attack is also the one which is appropriate for computations using standard International Business Machines punched card equipment.

In theory, computations intended for the Model V computer can be attacked on the column-by-column basis also. This plan of attack, however, is not a very satisfactory one if each column contains more than a few rows because the intermediate results obtained from any elementary operation must be retained in the machine while the operation represented by the next column is carried forward. If more than a few such intermediate results must be retained, it is necessary to make repeated use of the storage tape which slows down the operation of the machine. In most cases the computer is most effective if the computation is attacked on a row-by-row basis. Since the complete sequence of operations for any one row can be recorded on the routine tape, the computation of any other row merely requires that the tape be run through the machine again with a new set of parameter values inscribed on the problem tape. This is called a "sequential," as opposed to the column-by-column or "parallel" attack on the computation.

The fact that the organization of computations for the relay computer is normally sequential has a number of consequences. It introduces an element of flexibility in planning work for the machine, since it means that one need not choose all the individual cases of a given computation in advance, but may let some of them depend upon the results of the first cases computed. Moreover, it allows one to make some computations without waiting for the accumulation of a large number of such cases. Sequential problems are likely to include the majority of those in which mechanical computing is of scientific interest as a means of exploring relatively unknown phenomena, because it is only when individual computing sequences are long that we cannot expect to explore a problem well enough by manual computation to understand its major features.

When the problem is one containing many columns and few rows, special problems appear in the preparation of the control tapes. Repetitiveness is a practical necessity in any computing system, to keep coding effort within reasonable bounds. In a problem involving many cases (that is, many "rows") such repetitiveness appears automatically. We may find the necessary repetitive element even when the number of rows is quite small, however, by basing the procedure upon the repeated performance of a given cycle of operations with the starting point for each cycle obtained from the result of the preceding cycle. This may be called sequential repetitiveness. The step-by-step numerical solution of a differential equation is a process of this type. Iterative methods of obtaining better and better approximations to a complete solution, such as the Picard method of solving differential equations, also belong to this class.

Another problem which arises in preparing control tapes for sequential problems arises from the fact that when such long computing sequences are involved it may not be possible to foresee the course of the computation accurately. Thus, it is necessary to include in the control tapes instructions which will enable the machine to vary its procedure, depending upon the results it has obtained thus far. Thus, if a step-by-step calculation on a differential equation is being made, it may be desirable to shorten the step interval in regions which seem especially critical. If an iterative method, such as the Picard process, is being followed, we may wish to arm the computer with instructions for determining when an adequate approximation has been realized.

ILLUSTRATIVE PROBLEMS[*]

The Point Binomial Table. The first illustrative problem was taken from probability theory. Expanding $(q+p)^n$ according to the binomial theorem gives

$$(q+p)^n = q^n + nq^{n-1}p + \ldots + \frac{n!}{m!(n-m)!} q^{n-m}p^m + \ldots + p^n \qquad (7)$$

$$T_m = \frac{n!}{m!(n-m)!} q^{n-m}p^m = \frac{n-m+1}{m} \frac{p}{q} T_{m-1} \qquad (8)$$

In probability calculations q can be identified with the probability of an event's happening and p with the probability that it will fail to happen. Each term in the binomial expansion corresponds to the probability that the given event will happen a corresponding number of times in n trials. For example, the second term represents the probability of just one success in the n trials. The process of setting up this problem was so simple that it would not have been included normally in a program designed primarily to explore the machine's possibilities. However, tables of the terms in the expansion do not exist for n greater than 50, so the project of extending existing tables to n's between 50 and 100 furnished a very convenient backlog job. By keeping the point binomial problem constantly loaded on one of the positions it could be carried forward in snatches, in the intervals between work on other problems.

The Integral Cosine. In another problem the required result was a table of values of the integral of the *Ci*, or integral cosine, function with respect to the integral sine.

Simultaneous Equations. The third illustration was furnished by the solution of a system of simultaneous linear equations. The procedure followed is an elementary example of sequential repetitiveness. First, each member of each equation was divided by the coefficient of x_1 in that equation (unless that coefficient happened to be zero). The first equation which contained an x_1 term was then subtracted successively from all the others containing an x_1 term. In this way x_1 was eliminated from all the equations, while the number of equations was reduced from n to $n-1$. The same procedure was then applied to x_2 and so on.

There is a cumulative loss of accuracy due to rounding off errors in going through such a process as this. Serious inaccuracies must be expected in the computation if the determinant of the original coefficients is close to zero. As a means of improving the accuracy, the control tapes which were prepared for the problem included orders to substitute the calculated values in the original equations.

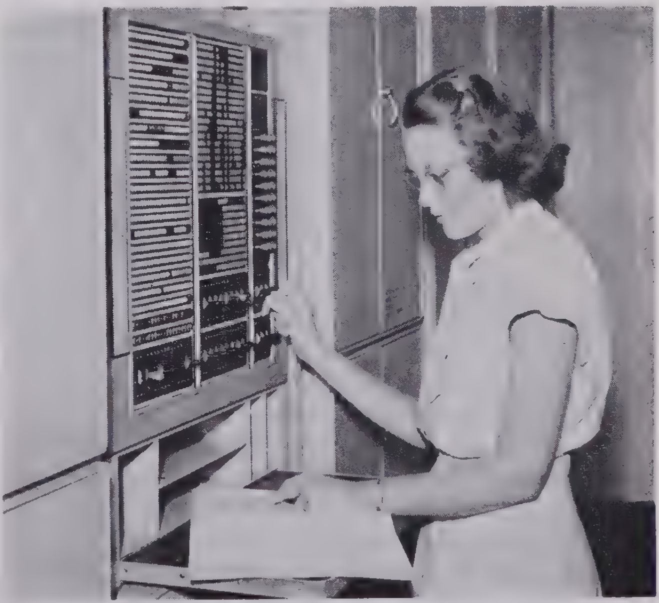

Figure 4. Lamp indicator panel

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[*] The authors are indebted to a number of their colleagues, and in particular to Dr. R. W. Hamming and Dr. H. Nyquist for the illustrative problems in this section.

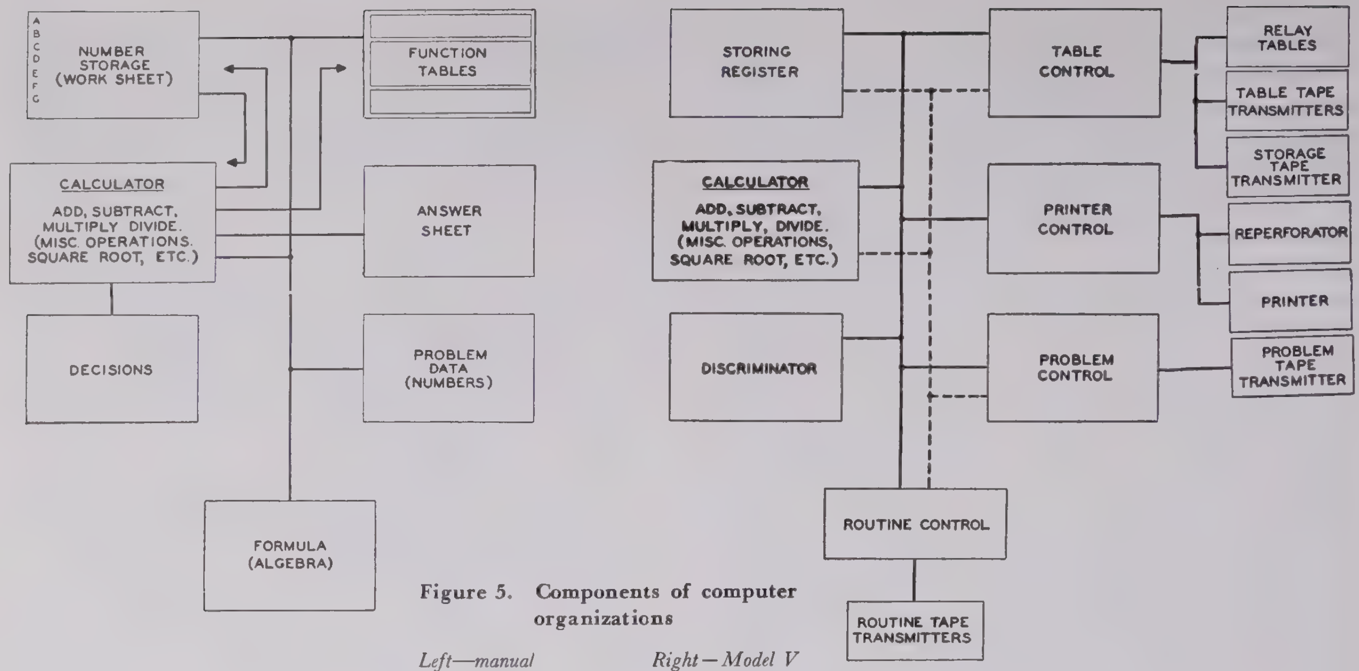


Figure 5. Components of computer organizations

Left—manual *Right—Model V*

The solution procedure was then repeated automatically, with the computed errors replacing the constants in the original equations.

Ordinary Differential Equations. The fourth type of problem was the solution of an ordinary differential equation for the movement of the armature of a relay. It is

$$\frac{dw}{dy}=\frac{C_L}{C_L-1}\,[1-(1+u)v] \tag{9}$$

$$\frac{d^2u}{dy^2}=-C_Fv^2 \tag{10}$$

where $v=w\dfrac{C_L-1}{C_L+u}$ and C_L and C_F are constants

At $y=0$, $u_0=u$, $w_0=0$, $\left.\dfrac{dw}{dy}\right|_0=0$, $\left.\dfrac{d^2u}{dy^2}\right|_0=0$

Program tapes for this problem were set up using several different methods, including the Picard method and ordinary step-by-step calculation. The principal problem in all these methods was that of choosing the step interval or other parameters in the approximating process in a way to secure accuracy and quick convergence without making the calculation unnecessarily long. This called for frequent use of the discriminating circuit. The step-by-step method, which is the most straightforward and predictable one, was perhaps the easiest to apply.

Partial Differential Equations. The fifth illustrative problem involved the solution of a partial differential equation for the penetration of magnetic flux into the center of a thin lamination. As eddy currents are induced near the surfaces of the strip a counter-field is produced which delays the buildup of magnetic flux at the center of the lamination and prevents it from reaching the value it would have if the external field were entirely effective.

If the material has constant permeability, the flux in any part of the strip corresponding to a sinusoidally varying external field is easy to determine analytically. The problem which the computer was asked to solve was that of finding numerically what happens in the interior of the lamination when the magnetic characteristics of the material are involved.

The partial differential equation relating the flux density, B, the field intensity, H, and the space and time co-ordinates x and t, x being the distance from the center of the lamination, is

$$\frac{\partial^2H}{\partial x^2}=\frac{4\pi\gamma}{c^2}\frac{\partial B}{\partial t} \tag{11}$$

Boundary conditions: $x=\pm\delta$ and $H=-2\cos 2\pi ft$
Initial conditions: $t=0$ and $H=-2$

The partial differential equation is approximated by the difference equation

$$B_n^{t+1/2}=B_n^{t-1/2}+\frac{c^2\Delta t}{4\pi\gamma(\Delta x)^2}\,\Delta^2H_n^t \tag{12}$$

Since there are two independent variables, differences in two dimensions must appear in the computation. To begin, values of the flux at all points in the strip are assumed when $t=0$. From the difference equation and the known values of the field on the surface of the strip, the values of B at time $t_1=\Delta t$ can be calculated. From these results B at time $t_2=2\Delta t$ can be determined, and so on.

The practical solution of a partial differential equation according to a procedure of the sort just outlined is one of the more difficult problems which the Model V computer may be called upon to confront. Instead of the simple one-dimensional array of points which occurs in the step-by-step solution of an ordinary differential equation, a lattice of two, or in general of n, dimensions must be considered. Thus the amount of computing is much greater, and the speed of solution becomes a serious question. Careful attention in the programming effort is needed to choose intervals which will permit a reasonably accurate solution without using more steps than are necessary. In making these choices allowance must also be made for the fact that the step intervals for the different independent variables must obey certain relations among themselves, irrespective of the question of nominal precision, if the solution is not to become oscillatory.

Another difficulty is the fact that a larger amount of information must be retained in the computer to perform the next step than would be necessary in an ordinary differential equation. This results from the fact that in order to advance one increment in time values of the function at all points for each of the two or three preceding times must be available, while in an ordinary differential equation only one point at each preceding time would be required. The amount of information which can be stored in the internal memory of the computer and the rapidity with which numbers can be read from it are very important.

The partial differential-integral equation for a traveling wave amplifier was also solved. The equations used were

$$\frac{dA(y)}{dy} = -\frac{1}{2\pi\epsilon}\int_0^{2\pi} \sin \Phi(\theta, y)\,d\theta \tag{13}$$

$$\eta(y) = -\frac{1}{2\pi\epsilon A(y)}\int_0^{2\pi} \cos \Phi(\theta, y)\,d\theta \tag{14}$$

$$\frac{\partial}{\partial y}\, q(\theta, y) = A(y) \sin \Phi(\theta, y) \tag{15}$$

$$\frac{\partial}{\partial y}\, \Phi(\theta, y) = K + \eta(y) + 2\epsilon q(\theta, y) \tag{16}$$

Analogue Problems. Problems in which the relay computer was used essentially as an analogue device were also solved. By giving the machine properly coded instructions it is possible in some cases to force it to become an analogue of a physical system. One example of such a calculation consisted in the study of the response of an oscillating system in which the parts included a good deal of backlash or lost motion. Because of the lost motion the operations of the system consisted essentially of discrete events occurring in a definite time sequence, and they could be represented as successive stages in a step-by-step numerical calculation.

OPERATING CHARACTERISTICS

The machine is versatile enough to be formally applicable to almost any problem. However, it has certain characteristics which tend to make it more appropriate for some types of problems than for others.

On the debit side, perhaps the principal weakness of the machine is its relatively slow speed. A second weakness is the number of registers available for immediate memory.

On the credit side, one of the chief virtues of the Model V computer is its direct and flexible programming system. This makes it possible to apply the machine to a wide variety of computations. The elaborate precautions which have been taken against faulty operation, and the self-checking features built into the computer, constitute a second strong point. These qualities are particularly valuable as prerequisites for unattended operation of the machine over nights and weekends.

CONCLUSIONS

Since addition, subtraction, multiplication, and division are the primary operations in computing, it is natural to suppose that the apparatus to perform these functions should be dominant in any digital computer. As a matter of fact, the most important parts of the design are those concerned with such auxiliary functions as the introduction of data, the storage of intermediate results, the recording of final results, and the control of the sequence of operations. In the Model V computer these auxiliary functions require nearly 80 per cent of the total apparatus.

The design of the apparatus to discharge the auxiliary functions is likely to be among the most critical and difficult problems in laying out any digital computer. As different computers adopt different mechanisms for discharging these functions they tend to develop "personality profiles" which make them particularly suited for one type of service.

Among the auxiliary functions none is of more decisive importance than that of remembering the intermediate results of calculations. The capacity of the memory unit, assuming it is satisfactory in other respects, is one of the most important elements in the "personality profile" of the machine.

A second major factor in determining the "personality profile" of the computer is the control system, in particular as it is related to the ease with which one can program a given problem. In the computers so far built, it seems fair to say that the effort required to program a given problem varies from arduous to back-breaking. This limits the application of computers to problems of the more ponderous type or to routine calculations involving a great deal of repetitiveness. One of the potential fields for digital computers is in the day-by-day solution of problems as they turn up in scientific work. For this sort of application a high level of programming ease is a prerequisite.

The third aspect of fundamental importance in digital computer design is the reliability and self-checking characteristics of the circuit. This aspect becomes particularly important as the scale and complexity of the problems envisaged for computers is increased. For an ordinary problem requiring a few thousand unitary operations an independent probability of error as great as one part in ten million for each individual operation might be reasonably satisfactory. This standard of reliability, however, would be quite inadequate for some of the problems considered for large scale computation, which may require hundreds of millions of unitary operations. In these problems a complex and strange situation may be under examination, and one cannot expect to pick out gross errors by inspection, as can be done in most ordinary computations.

A final prerequisite for the satisfactory use of a digital computer is the use of an adequate amount of auxiliary mathematical effort. It may seem at first sight that the possibility of exploring a situation extensively and at high speed by calculation should make any extensive study of the situation by ordinary analytic tools dispensable. Perhaps this is true so far as exact quantitative relations are concerned, but it takes only a brief experience with programming to demonstrate the importance of preliminary qualitative analysis of a problem in shaping an effective attack on it and in interpreting the calculations after they are made. Moreover, the detailed programming effort may raise auxiliary analytic problems itself.

Electrical Essays

Electrostatic Space Ship—Coulomb's Law and Force on an Electric Charge

In many books which I have looked at, it says that the force between two charges is

$$F=\frac{q_1q_2}{kr^2} \qquad (1)$$

where q_1 and q_2 are the strengths of the charges, r is the distance between them, and k is what they call the dielectric constant of the material in which the charge is. Some materials have awfully big dielectric constants such as some titanates with k more than 100. So if you put two charges inside a piece of titanate, the force between the charges will be 100 times smaller than if those charges were in air. But the books do not tell me what the force will be if only one of the charges is in the titanate. It would seem that the titanate would reduce the force on that charge which is inside it, but it certainly can have no effect on the other charge.

There would then be an unbalanced force on the two charges. As everybody knows now, I am a great inventor of space ships, and have worked out a good one based on displacement currents (*EE, Feb '49, pp 145–6*). However, like all great inventors, I am always on the lookout for new and better ways of doing the same thing, and this unbalanced force on charges looks as if it might have possibilities.

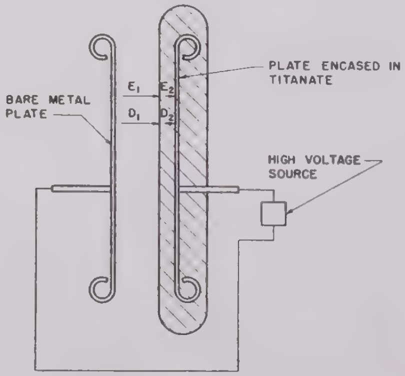


Figure 1. Electrostatic propellant for space ship

For the practical working out of my invention, I would use big plates of metal, near each other in pairs. One plate of each pair would be buried in titanate. The other would be bare. Figure 1 shows a section of one pair. I curve the edges so that I won't get fireworks out of the sharp edges like I see coming out of points on the high-voltage test floor. I would put the whole thing in a vacuum so that I can go up to high voltage between the metal plates.

The books say a lot about the arrangement in Figure 1. There is one electric field $\mathbf{E}_1=\mathbf{D}_1$ in the space outside the titanate. But in the titanate, they say that there are two fields which they call $\mathbf{E}_2$ and $\mathbf{D}_2$. The E field gives the force on the charge,

$$\mathbf{F}=\rho\mathbf{E} \qquad (2$$

The D field determines the charge by the relation

$$\text{div } \mathbf{D}=4\pi\rho \qquad (3$$

Then they say

$$\mathbf{D}=k\mathbf{E}, \text{ so } \mathbf{D}_1=\mathbf{E}_1,\ \mathbf{D}_2=100\ \mathbf{E}_2 \qquad (4$$

The charge per square centimeter, ρ, on the plates has to be the same for the two plates so $\mathbf{D}_1=\mathbf{D}_2$. Therefore $\mathbf{E}_1=100\ \mathbf{E}_2$. Hence by equation 2 the force on the bare plate will be 100 times as great as the force on the titanate covered plate.

On the bare plate, the books say the force is

$$F=4.4\times10^{-7}E^2,\ F \text{ in dynes per square centimeter, } E \text{ in volts per centimeter} \qquad (5$$

If I use $E_1=100{,}000$ volts per centimeter, I get $F=440$ dynes per square centimeter or about one-half gram per square centimeter. For a meter square plate then $F=$ 5 kilograms, so it won't take more than a few hundred of these plates to give a real powerful push for a quite sizable space ship. So now we have an "electrostatic space ship" to join my "electromagnetic space ship."

Question: Am I good!?

J. Slepian, Alter Ego

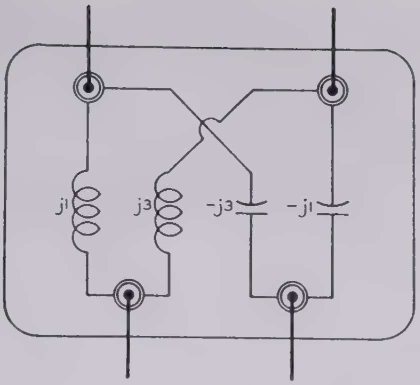
J. SLEPIAN (F '27
(Associate Director, Westinghouse Research Laboratories, East Pittsburgh, Pa.

Phase Sequence Indicator

An electrical engineer is preparing to place in service a motor-driven device. The motor is a 3-phase 60-cycle 208-volt direct-connected induction motor that must be operated in the correct direction of rotation from the start to prevent damage to the driven device. From available equipment the engineer assembles the "phase sequence indicator" illustrated in Figure 1. Two 60-watt 120-volt incandescent lamps and a 2-microfarad capacitor are connected in star (not grounded). When this indicator is connected to the 208-volt supply lines, one of the lamps will have impressed on it 120 volts and will glow with full brilliance. The other lamp will have impressed on it 88 volts and will glow with approximately one-third normal brilliance. The phase sequence then will be: (*1*) bright light; (*2*) dim light; and (*3*) capacitor.

The engineer first checks the three line voltages with an a-c voltmeter and finds them all equal to 208 volts. He

Figure 1. Phase sequence indicator



then connects the phase sequence indicator to the lines and finds that both lights glow with equal brilliance (nearly three-fourths normal).

What is the explanation of this phenomenon?

A. A. KRONEBERG (F '48)
(Southern California Edison Company, Los Angeles, Calif.)

Polyphase Windings

Some years back I was asked to investigate the possibility of changing to 18 póles, a 20-pole 400-horsepower 50-cycle 380-volt 3-phase slip-ring winder motor. Both stator and rotor had 2-bar-per-slot wave windings, the stator having 300 slots and two parallel paths, star-connected. The problem was to find out whether or not the same stator and rotor bars could be used just by reconnecting or rearranging the end connectors.

On the stator this was supposed to be impossible as the nearest possible number of slots for a symmetrical 18-pole 2-bar winding is 297. Nevertheless, it appeared to me to be quite possible to make an arrangement which, though physically somewhat unsymmetrical, is electrically quite symmetrical.

As the matter was very urgent in order to eliminate a certain bottleneck, and war conditions put out of the question ordering another motor, my suggestion was adopted, and in a few days the motor was ready and working successfully. It is still running well after about four years of the trying work to which these motors are subject, continually reversing, starting, and stopping, night and day, for months on end without rest.

After many months of successful operation under these conditions, I wrote to the chief designer of the British firm which had supplied this motor, asking his opinion and just stating the bare facts without explaining how the job was carried out. I thought it would be interesting to see what he would say in view of the fact that the machine was operating satisfactorily with perfectly balanced stator and rotor currents and everything else quite normal. His answer was that "it is impossible to get a balanced winding for 18 poles on this machine, but we consider that anyone conversant with motor windings should be able to divide the winding into the best number of groups; on the other hand, we consider that an experienced designer would not undertake the work without warning the owner of the grave risk of vibration. The fact that no vibration appears to occur, is due to the stator frame apparently being rigid enough; on a more modern machine, this might not be the case."

How was this 20-pole 3-phase slip-ring winder motor changed to an 18-pole machine?

M. P. ROMEIRA
(General Electric, S.A., Rio de Janeiro, Brazil

Answer to Previous Essay

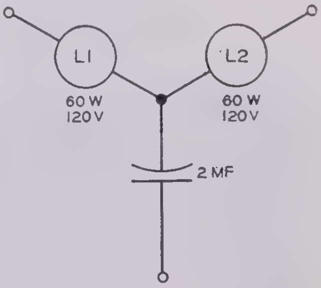
A Transformer. The following is the author's solution to a previously published essay of the foregoing title (*EE, Jan '50, p 51*).

There are more than enough clues in the engineer's description of his device to reproduce it.

Clue 6. There are no losses in this so-called transformer: therefore resistance is eliminated from consideration leaving inductance and capacitance for reconstruction of the circuit.

Clue 3. The transformer takes no exciting current. This clue indicates that viewed from the high side, the circuit is a parallel *LC* circuit with 60-cycle reactance ohms of both branches equal.

Figure 1. Circuit diagram showing connections and resulting values of reactances



Clue 2. The ratio of transformation is two to one. This clue indicates that the secondary terminals are connected to taps on one or both branches of the parallel *LC* circuit and are spanning one-half the reactance between primary terminals.

Clue 4. The series impedance of the transformer is zero and its secondary terminals should not be short-circuited. This clue indicates that both inductive and capacitive reactances are tapped in such a manner that a short circuit on the secondary terminals makes two series resonant paths for the primary current.

The resulting circuit of Figure 1 showing the connections and the relative values of reactances may then be checked against the remaining statements of the engineer in the electrical essay.

A. A. KRONEBERG (F '48)
(Southern California Edison Company, Los Angeles, Calif.)

INSTITUTE ACTIVITIES

Welding Technique Demonstrations Will Highlight Conference in Detroit

Practical demonstrations of electric welding techniques and equipment will supplement the 3-day AIEE Conference on Electric Welding scheduled for April 5–7 at the Rackham Memorial Building in Detroit, Mich. During morning and afternoon technical sessions, papers on arc and resistance welding will be presented, while meetings on two evenings will be devoted to demonstrations by authors and others. This will be the second welding conference to be sponsored by AIEE in co-operation with the American Welding Society and the Industrial Electrical Engineers Society in Detroit. Demonstrations are sponsored by the Detroit Section of the American Welding Society. More than 400 persons attended the first such conference held in December 1948. Papers and discussions were published in consolidated pamphlet form and are still available at $3.50 each from R. S. Gardner, AIEE Headquarters, 33 West 39th Street, New York 18, N. Y. A similar publication for the second conference may be ordered in advance at the same price.

The conference will open with two arc welding sessions devoted to arc research and welding equipment. An "instrumentation" session will consider both arc and resistance welding, while a "special welding processes" session will treat on stud welding, submerged arc welding, electric glass welding, induction welding, and so forth. The portion of the program devoted to resistance welding will cover both power supply problems and resistance welding machines.

Anyone interested in attending this conference may obtain an advance registration card by contacting E. D. Kane, Registration Chairman; Detroit Edison Company, 2000 Second Avenue, Detroit 26, Mich., or R. S. Gardner, AIEE Headquarters.

AIEE Sponsors Television Exhibit

Scene in the East Room of the Hotel McAlpin where the AIEE New York Section sponsored a television exhibition during the 116th Annual Meeting of the American Association for the Advancement of Science, December 26–31. Left to right, standing before an RCA Dynamic Demonstrator of a television receiving set, are: Dr. Frank Carvin, professor of electrical engineering at the Illinois Institute of Technology and a section engineer of the AAAS; Roy B. Shanck, Bell Telephone Laboratories engineer and chairman of the Communications Division, AIEE New York Section; I. E. Lattimer, American Telephone and Telegraph Company engineer, Long Lines Department, and head of the general committee arranging the exhibit and symposiums; and Scott Helt, of the research division, Allen B. DuMont Laboratories, Passaic, N. J., chairman of the subcommittee on exhibits. The exhibit was part of a 3-day joint session of AAAS and AIEE. It will be on view in the Penntop Room of the Hotel Statler during the AIEE Winter Meeting

Conference Subject to Be Improved Electronic Components

A conference on improved quality electronic components will be held in Washington, D. C., May 9, 10, and 11, 1950. I will be sponsored by the AIEE and the Institute of Radio Engineers in co-operation with the Radio Manufacturers Association.

The symposium will pose the problem of achieving the same high degree of dependability and service life in electronic equipments as is now possible in electric equipment of other types. The symposium will give emphasis to the following topics: improved quality of circuit elements for greater dependability of electronic equipments; unitized packaging as a means for greater dependability through simplified maintenance; miniaturization, particularly as applied to the unit package; circuit elements compatible with design requirements of the unit package.

The progress of research and development and the problems encountered in these fields will be reported by representatives of industry, the military services, and Governmental laboratories. Trends in the design and manufacture of electronic equipment will be discussed. Pertinent standards and specifications will be reviewed.

AIEE Nominating Committee to Meet During Winter Meeting

The Nominating Committee of the AIEE will meet at the Hotel Statler, New York, N. Y., January 31, 1950, during the Winter General Meeting of the Institute, to nominate candidates for AIEE offices to be voted on by the membership in the spring of 1950. Members of the committee follow.

Representing the Board of Directors are

A. H. Frampton, English Electric Company of Canada, Limited, St. Catharines, Ontario, Canada

M. D. Hooven, Public Service Electric and Gas Company, Newark, N. J.

F. O. McMillan, Oregon State College, Corvallis, Oreg

Elgin B. Robertson, Elgin B. Robertson, Inc., Dallas, Tex.

E. W. Seeger, Cutler-Hammer, Inc., Milwaukee, Wis.

Representing the ten geographical Districts:

1. C. E. Gaylord, New York Telephone Company, Buflalo, N. Y.
2. H. A. Dambly, Philadelphia Electric Company, Philadelphia, Pa.
3. D. W. Taylor, Public Service Electric and Gas Company, Newark, N. J.
4. J. Elmer Housley, Aluminum Company of America, Alcoa, Tenn.
5. Frank V. Smith, Sargent and Lundy, Chicago, Ill.
6. A. A. Little, Northwestern Bell Telephone Company, Omaha, Nebr.
7. C. V. Waddington, Kansas Gas and Electric Company, Wichita, Kans.
8. James L. Buckley, Pacific Gas and Electric Company, San Francisco, Calif.
9. R. B. Crow, Atomic Energy Commission, Richland, Wash.

10. Frank Noakes, University of British Columbia Vancouver, British Columbia, Canada

Alternates for Board representatives include:

A. C. Monteith, Westinghouse Electric Corporation, Pittsburgh, Pa.

C. G. Veinott, Westinghouse Electric Corporation, Lima, Ohio

Alternates for District representatives are:

7. H. P. Mathieu, Cabot Carbon Company, Pampa, Tex.

9. O. W. Hurd, Benton County Public Utility District, Prosser, Wash.

Future AIEE Meetings

Winter General Meeting
Hotel Statler, New York, N. Y.
January 30–February 3, 1950
(*Final date for submitting papers—closed*)

AIEE Conference on Electric Welding
Detroit, Mich.
April 5–7, 1950

AIEE Textile Conference
Georgia Institute of Technology
Atlanta, Ga.
April 13–14, 1950

AIEE Power Conference (Power Generation and Power Supply for Industrial Plants)
Hotel William Penn, Pittsburgh, Pa.
April 19–20, 1950

North Eastern District Meeting
Sheraton Biltmore Hotel, Providence, R. I.
April 26–28, 1950
(*Final date for submitting papers—closed*)

AIEE Conference on Electrical Engineering Problems in the Rubber and Plastics Industry
Portage Hotel, Akron, Ohio
May 5, 1950

AIEE Conference on Improved Quality Electronic Components
Washington, D. C.
May 9–11, 1950

Great Lakes District Meeting
Hotel Hayes, Jackson, Mich.
May 11–12, 1950
(*Final date for submitting papers—February 10*)

AIEE Conference on Telemetering
Philadelphia, Pa.
May 24–26, 1950

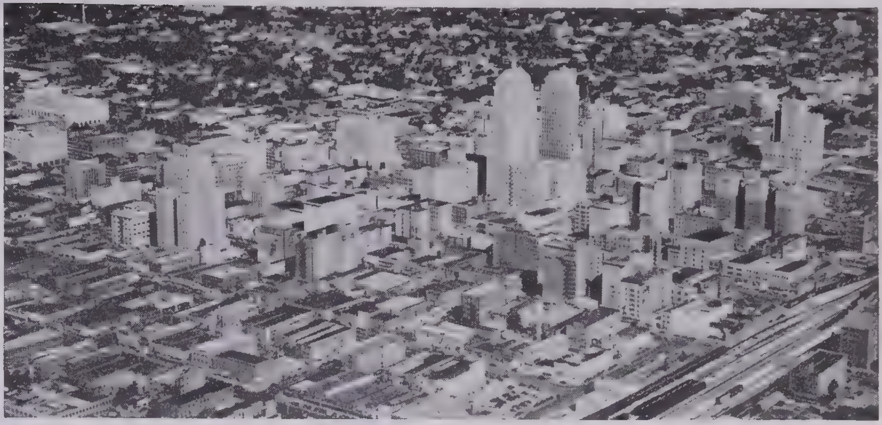
Summer and Pacific General Meeting
Huntington Hotel, Pasadena, Calif.
June 12–16, 1950
(*Final date for submitting papers—March 14*)

Middle Eastern District Meeting
Lord Baltimore Hotel, Baltimore, Md.
October 3–5, 1950
(*Final date for submitting papers—July 5*)

Fall General Meeting
Skirvin Hotel, Oklahoma City, Okla.
October 23–27, 1950
(*Final date for submitting papers—July 25*)

1951 Winter General Meeting
New York, N. Y.
January 22–26, 1951
(*Final date for submitting papers—October 24*)

1950 Fall General Meeting



Downtown Oklahoma City, where the 1950 AIEE Fall General Meeting will be held October 23–27, 1950, at the Skirvin Hotel, as it looks today. The city was "opened" for settlement on April 22, 1889, and by the end of the next day boasted a population of approximately 4,000 persons

North Eastern District to Meet in Providence

A 3-day meeting of the AIEE North Eastern District will be held in Providence, R. I., April 26–28, 1950. Headquarters for the meeting will be the Sheraton-Biltmore Hotel.

Arrangements are being made for a program of broad interest with several sessions on insulated conductors, the mining and metal industry, and computing devices. In addition, there will be a general session which is planned to interest a great many members.

The meeting also will afford an unusual opportunity to visit the various manufacturing plants in and about Providence to see the electrical applications in the public utilities and factories. Because of conditions which prevail in Providence, the committee recommends that it would be wise to make hotel reservations at the Sheraton-Biltmore Hotel as soon as possible and in advance of the receipt of the usual announcement of the meeting.

Winter Meeting Program Adds Industrial Spectroscopy Session

The following addition has been announced to the tentative technical program for the 1950 Winter General Meeting (*EE, Jan '50, pp 74–7*). On Tuesday, January 31, at 9:30 a.m., a Symposium on Industrial Spectroscopy will be held in Parlor 1 of the Hotel Statler. At this symposium, informal papers will be given concerning the various aspects of problems encountered in the field of industrial spectroscopy with special emphasis placed on the subject of instrumentation.

The scheduling of this informal symposium marks one of the first functions of a newly

County Courthouse in Providence, R. I., which has been selected as host city for the 1950 North Eastern District Meeting in April

formed Subcommittee on Industrial Spectroscopy of the AIEE Committee on Instruments and Measurements. This subcommittee will be under the chairmanship of Dr. John H. Enns of the University of Michigan, Ann Arbor, Mich.

AIEE/IRE Student Branch Installed at the Rhode Island State College

With the holding of a banquet on the evening of November 16, 1949, Student members of the AIEE and the Institute of Radio Engineers marked the installation of an AIEE/IRE Student Branch at Rhode Island State College in Kingston, R. I. Professor W. H. Timbie of the Massachusetts Institute of Technology acted as toastmaster for the evening.

The main speaker at the meeting was Dr. A. G. Conrad, Professor and Chairman of the Electrical Engineering Department at Yale University, New Haven, Conn., who was introduced by W. B. Hall, head of the Rhode Island State College Electrical Engineering Department. Speaking on the subject, "Effects of Engineering Education on Social Progress," Dr. Conrad pointed out the rapid increase in improved living conditions brought about by the engineer, and that it is up to the young engineer to provide other means of improving living conditions without destroying our natural resources.

The new Student Branch was welcomed for the AIEE by Victor Siegfried, American Steel and Wire Company, who is Vice-President of the AIEE North Eastern District; for the IRE by Professor H. J. Reich of Yale University, IRE Regional Director; and for the American Society for Engineering Education by W. C. White of Northeastern University, Chairman of the ASEE New England Section.

The response to the welcome was given by Louis A. Coppolino, President of the Rhode Island State College AIEE/IRE Student Branch.

Seated, left to right, are: Mrs. Fred Garrison, Ladies' Committee; M. V. Eardley, Vice-Chairman; Fred Garrison, General Committee Chairman; and E. L. Bettannier, Secretary, who, with their other committee chairmen or alternates, are conferring on ways to make the coming Summer and Pacific General Meeting in Pasadena, Calif., the "biggest and best meeting yet"

Committee Cautions Against Plans to Stay After Summer Meeting

As announced previously, the 1950 AIEE Summer and Pacific General Meeting will be held June 12–16 in Pasadena, Calif., with headquarters at the Huntington Hotel. However, realizing that many prospective visitors to the meeting, with vacations in mind, are planning their trips even now, the General Committee for the meeting wishes to point out that no reservations will be available after Saturday, June 17, 1950. The Shrine Convention will be held immediately following the AIEE meeting with an expected attendance of 125,000 which means that "every bed, every park bench, and the sheltered spots on the beaches will be reserved for them." It is suggested that AIEE members continue their post-meeting trip through Central California, San Francisco, and the Northwest, if time permits.

The meeting committees are continually working to produce a 1950 Summer meeting that will be even more successful than those in previous years. As plans for the meeting materialize, they will be reported in subsequent issues of *Electrical Engineering.*

Participating in the recent banquet marking the installation of an AIEE/IRE Student Branch at Rhode Island State College are seen, left to right: Professor H. J. Reich, Regional Director of IRE; Professor W. B. Hall, Rhode Island State College; Dr. A. G. Conrad, guest speaker; and Professor W. H. Timbie, toastmaster

1951 Winter General Meeting Committee. The following have been appointed members of the general committee to make plans for the annual Winter General Meeting which is to be held in the Hotel Statler, New York, N. Y., January 22–26, 1951:

G. J. Lowell (Chairman), W. J. Barrett, D. T. Braymer, C. T. Hatcher, N. S. Hibshman

In addition, the 1950–51 holders of the following offices are to be appointed to the committee:

Vice-President of District 3, Secretary of District 3, Chairman of New York Section, Junior Past Chairman of New York Section, Chairman of Technical Program Committee, Chairman of Committee on Public Relations

SECTION • • • • • • •

Dr. K. B. McEachron Speaks at Richland Section Meeting

Dr. Karl B. McEachron, Manager of Engineering for the General Electric Company's Transformer and Allied Products Division at Pittsfield, Mass., discussed the subject of "Lightning and Lightning Protection" at a meeting of the AIEE Richland (Wash.) Section on October 26, 1949. The discussion by this outstanding authority on lightning characteristics and the protection of electric apparatus was devoted primarily to an explanation of lightning phenomena, the historical background of research, and the features of a practical and reliable protective system.

In 1922, when Dr. McEachron returned to the General Electric Company to take charge of research in the Lightning Arrester Engineering Department, he was assigned two specific tasks: to discover methods and instruments to measure natural lightning; and to reduce these facts to records available for the guidance of the designers of electric apparatus. During the subsequent years of investigation, it was discovered that natural lightning and laboratory-created artificial lightning flashed over strings of disk insulators in the same manner. The fact was thus established that the engineer's laboratory and test equipment would reproduce the conditions found in natural lightning and so the engineers were able to proceed with considerable confidence that what they were doing in the laboratories was the same thing that was occurring in the field. The latest and most modern of these laboratories is the recently completed General Electric High-Voltage Laboratory at Pittsfield where 15-million-volt lightning strokes are created over distances of 50 feet, either indoors or outdoors (*EE, Aug '49, p 745*).

The meeting was closed by an extended question and answer period during which Dr. McEachron analyzed conditions which should be considered, in specific installations, to protect property and life from damage due to lightning. Dr. McEachron emphasized the fact that lightning protection is relatively simple, and in many instances not very costly when the designer carefully considers the location of all structural features such as water piping, steam lines, structural steel, reinforcement steel in concrete and cement, other buildings, and the shape of the earth's surface. He further stated that most damage has actually occurred due to the failure to take into consideration all of the conditions present.

New York Section to Sponsor Student Branch Get-Together

On February 21, 1950, the AIEE New York Section will sponsor a Student Branch get-together of all the colleges in the Metropolitan area. The ten colleges involved include Brooklyn Polytechnic Institute, City College of New York, Columbia University, Cooper Union, Manhattan College, Newark College of Engineering, New York University, Pratt Institute, Rutgers University, and Stevens Institute.

AIEE President James F. Fairman will address the student group at the meeting, and William Keister of the Bell Telephone Laboratories will present a demonstration lecture on "Automatic Control With Relays." Refreshments will be served following the general meeting.

Erie Section Organizes Ridgway, Pa., Subsection

A Ridgway Subsection of the AIEE Erie Section was organized at a meeting of the Erie Section held in Ridgway, Pa., on December 7, 1949. The Pennsylvania counties of Cameron, Elk, and McKean were assigned to the new Subsection.

Officers elected to serve the Subsection until May 31, 1950, are A. A. Jedrziewski, Assistant Division Engineer, West Penn Power Company, Pittsburgh, Pa., as Chairman; and J. H. Schneider, Section Engineer, Elliott Company, Ridgway, as Secretary-Treasurer.

Niagara Frontier Section to Celebrate 25th Anniversary

With a banquet meeting at the Hotel Statler, Buffalo, N. Y., on February 16, 1950, the AIEE Niagara Frontier Section will mark the 25th anniversary of its founding. The Section will be honored on this occasion by a visit from AIEE President James F. Fairman and District 1 Vice-President Victor Siegfried. The AIEE Niagara International Section has been invited to join in the celebration.

Through the past quarter of a century the Niagara Frontier Section has grown from the original 29 charter members in 1925 to a present membership of approximately 200 persons. Suitable recognition is planned for those charter members still living and residing in the area. Recognition will also be given of services rendered by past Section chairmen.

Present officers of the AIEE Niagara Frontier Section include Chairman F. C. Rushing of the Westinghouse Electric Corporation and Secretary-Treasurer C. J. Brumbaugh of the New York Telephone Company, both of Buffalo. G. W. Eighmy is acting as Publicity Chairman for the Section's 25th anniversary program.

AIEE Albuquerque Subsection, Reorganized, Holds Meeting

With M. V. Kievert, Jr., of the Raymond Rosen Engineering Products, Inc., Philadelphia, Pa., as guest speaker, the Albuquerque Subsection of the New Mexico–West Texas Section of the AIEE met on November 3, 1949, in the Science Lecture Hall on the University of New Mexico campus. This meeting of the Subsection was one of its most important since its re-establishment in April 1949 after an extended lapse of inactivity. Within the past year, a large number of electrical engineers have located in the Albuquerque area, due principally to the Sandia Corporation now operated by the Western Electric Company, which was formerly the Sandia Laboratory

Philadelphia Section Officers for 1949-50

Shown here are the officers, Board of Managers, and committee chairmen of the AIEE Philadelphia Section for 1949–50. First row, left to right: W. R. Clark, Senior Past Chairman; E. W. Randall, Jr., Wilmington Subsection Chairman; S. R. Warren, Jr., Vice-Chairman; W. F. Henn, Chairman; H. H. Sheppard, Secretary; M. J. A. Dugan, Treasurer; A. P. Godsho, Junior Past Chairman; B. H. Zacherle, Chairman, Fellowship and Attendance Committee. Second row, left to right: C. R. Kraus, Chairman, Educational Committee; C. T. Pearce, Chairman, Special Advisory Committee; G. C. Harness, Member, Board of Managers; L. R. Gaty, Member, Board of Managers; W. F. Denkhaus, Member, Board of Managers; S. L. Gibble, Member, Board of Managers; K. Pinder, Member, Board of Managers; J. B. Colemen, Member, Board of Managers; W. L. Pitts, Acting Chairman, Discussion Group Committee; R. T. Ferris, Chairman, Publicity Committee. Top row, left to right: F. C. Powell, Chairman, Student Activities Committee; G. B. Schleicher, Chairman, Prize Papers Committee; F. H. Wyeth, Chairman, Communications Group Committee; H. A. Dambly, Chairman, Stein for President Committee; O. A. Huntsman, Chairman, Related Activities; C. S. Westervelt, Chairman, Membership Committee; W. E. Scholz, Representative, Technical Service Council; C. L. Schuck, Assistant to the Secretary

Attending a meeting of the AIEE Albuquerque Subsection on November 3, 1949, are shown, left to right: L. C. Trussler, American Telephone and Telegraph Company, Program Committee Chairman; M. V. Kievert, Jr., Raymond Rosen Engineering Products, Inc., Philadelphia, Pa., guest speaker; Professor J. L. Ellis, University of New Mexico, Arrangement Committee Chairman; A. D. Taylor, Sandia Corporation, Secretary-Treasurer; H. C. Biggs, Sandia Corporation, Membership Committee Chairman. W. O. McCord, Jr., Sandia Corporation, Subsection Chairman, and H. S. Westcott, Jr., Sandia Corporation, Publicity Committee Chairman, are not in this group

operated by the University of California for the Atomic Energy Commission, in addition to the Kirtland Air Force Base, both located in the Albuquerque vicinity. The Albuquerque Subsection's territory includes the cities of Albuquerque, Santa Fe, and Los Alamos, and the intervening territory. The members located at Los Alamos are employed at the Los Alamos Scientific Laboratory operated by the University of California for the Atomic Energy Commission. The Subsection's total membership as of December 1949 numbered 80.

At the November 3 meeting, Mr. Kiebert's topic was "Aeronautical Telemetering" which covered aeronautical problems in relation to telemetering, the scope of present telemetering systems, telemetering information transmission, telemetering systems in common use, typical air-borne transmitters, ground receiving systems, and standardization programs and problems, also other applications such as in the civil aeronautical field, in flood forecasting, for industrial uses, and the like. This meeting coincided with the tenth annual meeting of the National Telemetering Forum which convened in Albuquerque November 3 and 4, from which many members attended the Subsection's meeting.

The Albuquerque Subsection also was invited to participate in a joint meeting with the local sections of the Institute of Radio Engineers and the Instrument Society of America, and the National Telemetering Forum, on November 4, 1949, at which W. H. Hewlitt of the Hewlitt Packard Company, Palo Alto, Calif., spoke on "Transient Response of Distributed Amplifiers." Approximately 150 persons attended the joint meeting.

AIEE Savannah Subsection Holds Organization Meeting

A Savannah Subsection of the AIEE Georgia Section has been organized, and an organization meeting was held on December 1, 1949, in the "Reddy Kilowatt" Room of the Savannah Electric and Power Company, Savannah, Ga. E. H. Overby of the Union Bag and Paper Corporation served as Chairman of the Committee on Arrangements for the meeting.

Professor W. J. Seeley, Duke University, Durham, N. C., who is Vice-President of AIEE District 4, was a featured speaker at the organization meeting of the Savannah Subsection. Other speakers included E. S. Lammers, Westinghouse Electric Corporation, Atlanta, Ga., who is Chairman of the Georgia Section; J. M. Raney, Georgia Power Company, Atlanta, Vice-Chairman of the Georgia Section; and H. P. Peters, Georgia Institute of Technology, the AIEE Georgia Section's Secretary-Treasurer.

Organizers of the Savannah Subsection of the AIEE Georgia Section, reading from left to right: C. L. Drummond, Georgia Power Company, Chairman of the Georgia Section Papers Committee; J. R Raney, Georgia Power Company, Vice-Chairman of the Georgia Section; M. T. McKenzie, Savannah Electric and Power Company; H. F. E. Schuster, United States Corps of Engineers, Subsection Secretary; R. F. Sorrenson, Union Bag and Paper Corporation; E. S. Lammers, Jr., Westinghouse Electric Corporation, Chairman of the Georgia Section; and E. H. Overby, Union Bag and Paper Corporation, Subsection Chairman

COMMITTEE ACTIVITIES

Editor's Note: This department has been created for the convenience of the various AIEE technical committees and will include brief news reports of committee activities. Items for this department, which should be as short as possible, should be forwarded to R. S. Gardner at AIEE Headquarters, 33 West 39th Street, New York 18, N. Y.

Industry Group

Committee on Feedback-Control Systems. (*Gordon S. Brown, Chairman; S. W. Herwald, Vice-Chairman; H. T. Marcy, Secretary.*) The activities of the Joint Subcommittee on Servomechanisms have now been established at full committee status with the designation, Committee on Feedback-Control Systems (Industry Group). The activities of this new committee cover the treatment of matters in which the dominant factors are the terminology, requirements, design, construction, and operation of equipment and the circuits pertaining to control systems involving feedback, such as servomechanisms, regulators, and governors, excluding measuring and recording instruments. This committee will co-operate with other technical committees within the Institute interested in servomechanisms, regulators, or other control systems, as well as with related committee work in associated societies.

Feedback-control systems are encountered throughout the entire gamut of industry, specifically in the control of position, voltage, speed, pressure, temperature, the properties of many quantities in process industries, in the navigation and piloting of aircraft and ships, and in many aspects of the behavior of human beings. A feedback-control system is often explained in terms of a person driving his automobile, where the command is the direction of the highway, the error-detecting system is the eyes and senses of the driver, and the amplifiers and servomotor are the human nerve system, muscles, and the steering wheel which bring about control in vehicle heading to minimize the error between the direction the vehicle should be going and the direction in which it is going. Steering an automobile involves a feedback-control system in which the human being is a vital part of the feedback and the feed-forward link.

Committee on Industrial Control. (*G. W. Heumann, Chairman; John A. Cortelli, Vice-Chairman; H. L. Palmer, Secretary.*) The following paragraphs contain a brief report on the activities of the subcommittees of the Committee on Industrial Control.

Subcommittee on Bibliography (R. W. Jones, Chairman) is now completing the final draft of the bibliography on industrial control. It is anticipated that this bibliography will be published during 1950. The references contained in this bibliography pertain to motor characteristics and the circuits which are used in the field of industrial-type motor controls. Each reference contains a short abstract, and all significant references both of American and foreign origin have been included.

Subcommittee on Test Codes (C. T. Evans, Chairman) is engaged in the development of a test code for industrial control apparatus. The project under active discussion at present is the testing of contacts to ascertain various contact characteristics.

Subcommittee on Standards (G. W. Heumann, Chairman) has completed its work on revisions of ASA *C19.1* (AIEE *15*, "Standard for Industrial Control Apparatus") and ASA *C42* ("Definition of Electrical Terms"). These proposals are now being considered by the proper American Standards Association committees.

Subcommittee on Electronic Control (H. L. Palmer, Chairman) held a successful technical conference in Buffalo on April 11–12, 1949, jointly with the AIEE Committee on Electronics. This conference was well attended. Proceedings have been published and can be purchased from AIEE Headquarters. Several working groups are actively engaged in preparing definitions of processes and functions to be controlled. It is intended to have those definitions discussed with other bodies who are working in related fields and to arrive eventually at ASA standard definitions.

Subcommittee on Regulators and Feedback-Control Systems (O. W. Livingston, Chairman), which was formerly a subgroup of the Subcommittee on Electronic Control, was raised to full subcommittee status at the fall meeting of the Committee on Industrial Control. This subcommittee will treat all matters within the scope of the main committee concerning classifications, definitions, specifications, Standards, design, and application of regulators and feedback-control systems. This subcommittee will co-operate with other groups in AIEE or other technical societies engaged in similar work. At the initial meeting of the subcommittee, it was decided to concentrate its attention on definitions and classifications. This group will appreciate any suggestions or any material on this subject from other interested individuals or groups.

Power Group

Committee on Substations. (*G. S. Lunge, Chairman; R. C. Ericson, Vice-Chairman; Marino Fraresso, Secretary.*) Certain of the contemplated projects (*EE, Aug '49, p 731*) have taken more definite form, as follows. The first two projects are sponsored by the Transmission Substation Subcommittee, the last one by the Working Group on Fundamental One-Line Diagrams, and the remainder of the projects are sponsored by the Distribution and Conversion Substations Subcommittee.

Basic Structural Design of Transmission Substations. This study will include structures for voltages 110 kv and above. A report is in preparation covering the more common variables of structure design and how voltage classifications govern types of structures. The report will reflect the present-day practice of using light metals in the basic design.

Safety Considerations in Substations. A report is in preparation evaluating safety as applied to personnel from a design standpoint and operating practice, and functional designs required for operational and system safety requirements.

Bus Regulation Versus Feeder Regulation. The electrical utilities have attempted to maintain, and are still confronted with the paradoxical problem of maintaining, their historical and traditional policy of holding the line against an increase in rates in the face of increased costs of equipment, labor, and fuel.

Because of the greater reliability of equipment, coupled with a more exact knowledge of system characteristics to which each piece of apparatus is to be subjected, changes in basic design for substations are being accepted as one means of decreasing system investment without seriously and adversely affecting system reliability. Utilities that have heretofore considered individual feeder regulation essential for a radial system are considering and installing bus regulation as a means of decreasing capital costs and achieving station simplification.

The Distribution and Conversion Substations Subcommittee has chosen a study of this subject as its number one priority project. The purpose of the study is to determine the advantages and limits that obtain with bus regulation, to review the experiences of utilities, and prepare recommendations on its use. Suggestions or comments regarding actual experiences with bus regulation will be welcomed by the subcommittee.

Circuit Breakers Versus Reclosing Fuses for Small Substations. This project is to include service security and relative economy provided by circuit breakers with or without reclosures versus reclosing fuses at simple distribution substations.

Basic Structural Designs of Outdoor Substations. This project is to include practices regarding providing or omitting structures for substations located in residential and commercial areas.

Lighting of Outdoor Substations. This project is to include a guide covering lighting practices for outdoor substations setting forth recommended illumination layouts, footcandles required, placing of floodlighting and other lighting fixtures.

Standardized Construction of Package and Other Substations. This project is to include economic possibilities in the standardization of manufacturers' package substations.

Fundamental One-Line Diagrams. Postwar conditions have brought about a gradual elimination of nonessential items from substation installations, with the result that modern thinking is tending toward a few simplified basic concepts of station design. Recognizing that a study looking toward a unified and approved station design is of paramount importance—as expressed in the initial one-line basic diagram—a working group of personnel from both the Distribution and Transmission Substations Subcommittees has been chosen to review existing practices and previously published papers, and to obtain current opinions on the subject among utility engineers to determine present trends in design with the ultimate goal of recommending uniformity of arrangement and standardization of equipment to best meet the average conditions.

Committee on Transmission and Distribution. (*I. W. Gross, Chairman; S. B. Crary, Vice-Chairman; R. E. Pierce, Secretary.*) Among the activities planned for the coming year by the subcommittees of the Transmission and Distribution Committee are the following:

1. Further study on power capacitors centering around standardization of temperatures, corrosion of tanks, short-time voltage ratings of series capacitors, and keeping up to date a continuous bibliography on the subject.

2. Distribution system economics is one of the main subjects on the Distribution Subcommittee's list on which it is expected progress will be made.

Another activity being carried on jointly with the Transmission and Distribution Committee of Edison Electric Institute is an investigation of operating experience on distribution lines and circuits.

3. The study project on transmission line outages, also a joint activity with the Edison Electric Institute Transmission and Distribution Committee, reported in the September issue (*EE, Sep '49, p 816*), is being accelerated

4. A subject of interest to the transmission field which has not yet become active is a further investigation of magnitude and wave shapes of switching surge voltages on high-voltage lines.

5. The Lightning and Insulator Subcommittee is nearing the completion of its project of preparing a bibliography of technical articles which financial reasons made it impossible to include in a separate Lightning Book, volume 2. This project is scheduled for completion in the spring of 1950.

6. A committee report on precalculating the lightning performance of lines is in the course of preparation.

7. The study of impulse strength of insulators, wood, and air in series, which was interrupted due to destruction of laboratory facilities, is on the committee program

8. An investigation of impulse and 60-cycle wet flashover of standard suspension insulators in the range of 20 to 25 units is also projected.

9. Some items receiving consideration by the Towers, Poles and Conductors Subcommittee are: economics of wood against steel structures; maximum conductor currents without annealing; conductor fatigue from vibration; galloping conductors; and co-ordination of system requirements with meteorological and weather forecasting authorities.

Important factors affecting projected high-voltage lines which include corona, radio influence, series capacitors, and economics are under consideration, and it is expected that papers on this very important phase of transmission will soon be forthcoming.

Science and Electronics Group

Joint Subcommittee on Telemetering. (*C. K. Duff, Chairman; J. L. McKee, Secretary.*) A Special Technical Conference on Telemetering, sponsored by this joint subcommittee and the National Telemetering Forum, is being planned for May 1950. This will be the first national conference dealing with all types of telemetering, wire, radio, and mobile, and is expected to arouse a great deal of interest.

Conference Chairman is W. J. Mayo-Wells, a member of this joint subcommittee and Chairman of the National Telemetering Forum which was organized in 1948 to co-ordinate telemetering mainly in the mobile-radio telemetering field. It is believed that there will be considerable value in a joint conference where older and newer methods of telemetering may be compared. P. A. Borden is chairman of the Program Committee. Dates and location of the conference will be announced in the near future.

Activities of the joint subcommittee in the field of telemetering terms and definitions have led to the appointment of a Subcommittee on Telemetering Terms. This subcommittee, headed by Mr. Mayo-Wells, is to include in its work a study of mobile-radio telemetering terms partially completed by a Working Group on Telemetering of the Research and Development Board which is co-operating in this project.

AIEE PERSONALITIES.....

Zay Jeffries (M '36, F '42) of Pittsfield, Mass., Vice-President of the General Electric Company in charge of the Chemical Department, has retired. During the war, Dr. Jeffries was Vice-Chairman of the War Metallurgy Committee and Chairman of two of its subcommittees. He also served as consultant for the University of Chicago metallurgical laboratory, part of the Manhattan Project for research and development work on the atomic bomb. He has been a member of General Electric's 4-man committee which administers the Nucleonics Project, consisting of all work on atomic energy being conducted by the company for the government. Dr. Jeffries was educated at the South Dakota State School of Mines and received his Doctor of Science degree at Harvard University. In 1911, Dr. Jeffries joined the faculty of the Case School of Applied Science and in 1915 became director of research for the Aluminum Castings Company, later being named Consulting Metallurgical Engineer for the Aluminum Company of America. He began service with General Electric in 1914 as a consultant to the National Lamp works. From 1932 to 1936 he was also president of the Carboloy Company, Inc., a General Electric affiliate, and since then has been a member of the board. In 1936, he became technical director of the General Electric Lamp Department. In January 1945, Dr. Jeffries was elected a vice-president by the General Electric Board of Directors and placed in charge of the newly formed Chemical Department. In 1945, Dr. Jeffries was awarded the John Fritz Medal of 1946, for leadership in the solution of problems affecting the production, conservation, substitution, and the scientific appraisal of metals and alloys. In 1948, he received the Medal of Merit for services with the War Metallurgy Committee in World War II. Dr. Jeffries is a member of the National Academy of Sciences, American Institute of Mining and Metallurgical Engineers, American Institute of Physics, American Society for Metals (honorary member and past president), American Association for Advancement of Science, Cleveland Engineering Society (honorary member), Franklin Institute, Institute of Metals of Great Britain, American Chemical Society, American Philosophical Society, and Newcomen Society. He is also a fellow of the American Physical Society.

Matthew Luckiesh (A '11, F '40, Member for Life), Director of the General Electric Company's Lighting Research Laboratory at Nela Park, Cleveland, Ohio, for the past quarter century, retired on December 31. Noted for his pioneer work in the study of the visible spectrum, as well as his scientific explorations into the fields of invisible infrared and ultraviolet energy, his findings in these fields are included in 24 books and in hundreds of technical papers he has written during his two score years with General Electric Company. His latest researches have been devoted to use of germicidal energy in the killing of air-borne and water-borne bacteria. A native of Iowa, Dr. Luckiesh attended Purdue University where he received his Bachleor of Science degree in Electrical Engineering. He received his Master of Science degree from the State University of Iowa and his degree of Electrical Engineer from Iowa State College. He received his Doctor of Science degree from Iowa State in 1926 and his Doctor of Engineering degree from Purdue in 1935. Dr. Luckiesh has been extremely active in the affairs of the Illuminating Engineering Society, having served as Chairman of its various committees, as a Director, and as its President. Dr. Luckiesh joined the General Electric organization in 1910 as a Physicist in the Research Laboratories of the company's Lamp Department in Cleveland. In 1920 he was elevated to the position of Director of Applied Science, which post he held until 1924, when he was named director of the department's Lighting Research Laboratory. Dr. Luckiesh conceived and directed many lamp and lighting developments. Among them were: the first accurate glass filters for the production of artificial daylight; daylight lamps; flametint lamps; meters for measuring light, ultraviolet, brightness, visibility, and bacteria content of the air; and lighting recipes for residential, commercial, and industrial needs. In addition to being a member of the Illuminating Engineering Society, Dr. Luckiesh is a member of the Edison Electric Institute, American Physical Society, Franklin Institute, and the Optical Society of America. He made notable contributions in both world wars in the fields of visibility and camouflage.

R. H. Barclay (A '14, M '18, F '28, Member for Life), formerly Chief Electrical Engineer, Electrical Engineering Department, J. G. White Engineering Corporation, New York, N. Y., has been promoted to Engineering Manager of the company. Mr. Barclay, who was recently elected Chairman of the Committee on Professional Recognition of the Engineers' Council for Professional Development, has been with J. G. White since 1941. An alumnus of Washington University he spent the early part of his career working for electrical companies in Missouri. Coming to New York, he joined the Brooklyn-Manhattan Transit Corporation in 1915 as Assistant Electrical Engineer. From 1917 to 1922, Mr. Barclay was employed as Chief Electrical Engineer for The Foundation Company, New York, N. Y., where he was responsible for the electrical engineering and electrical construction of a large number of loading plants, shipyards, and vessels. After associations with Starrett and Van Vleck, Architects, New York, N. Y., the Stone and Webster Corporation, Boston, Mass., and McClelland Barclay Art Products, Inc., New York, N. Y., he was appointed to the Federal Power Commission in 1934. Four years later, he was expert adviser to the Joint Committee on Investigation of the Tennessee Valley Authority on matters relating to the design, construction, operation, and integration of the power generating facilities of the TVA. Mr. Barclay has been serving on the AIEE Board of Examiners from 1943 to the present time, acting as Chairman during the interval 1946–48. He also was a member of the Board of the Engineering Societies Library from 1942 to 1948, having been Chairman, 1946–48. At one time, he served on the AIEE Marine Committee.

A. A. Johnson (A '32, M '44) has been appointed Manager of Central Station Engineering in the Industry Engineering Department of the Westinghouse Electric Corporation, East Pittsburgh, Pa. He succeeds **C. F. Wagner** (A '20, F '40) who has recently been named Consulting Engineer for the company. In his new position, Mr. Johnson will co-ordinate engineering activities of the company on problems of genera-

Zay Jeffries

Matthew Luckiesh

R. H. Barclay

tion, transmission, distribution, and system protection for electrical utilities and large industrial plants. Graduated from the University of Virginia in 1930, he was employed the same year by the Consolidated Edison Company of New York, N. Y., where he spent 11 years doing engineering work. He came to the Westinghouse Electric Corporation in 1941 in the Central Station Section of Industry Engineering. Since then he has handled consulting engineering problems for electrical utilities and manufacturing plants. At present, he is serving on three AIEE committees: Protective Devices; System Engineering; and Transformers.

Guy Kleis (A '48) has been named Manager of the entire educational department of the Westinghouse Electric Corporation at East Pittsburgh, Pa. In his new position, Mr. Kleis will supervise university relations, student recruitment, and the graduate student training programs. The university relations group administers numerous Westinghouse scholarships and fellowships and co-operates with many colleges and universities in providing advanced degree courses for Westinghouse employees. The student recruitment group handles the selection and hiring of all college level people for the entire corporation. The graduate student training course combines work assignments and classroom study programs to bridge the gap between college and industry. The student is given training in the practical application of theory and acquainted with Westinghouse products and operations. A native of Holland, Mich., Mr. Kleis received a Bachelor of Arts degree from Hope College and a Bachelor of Science degree from the University of Michigan in 1937. That same year he joined Westinghouse and was assigned to the Switchgear Sales Department. In 1946, following the war, he transferred to the Educational Department as Supervisor of Engineering Training, and, in 1947, became Manager of Graduate Student Training.

T. D. Talmage (M '40), formerly Principal Communication Engineer with the Tennessee Valley Authority, Chattagnooga, Tenn., has been appointed Assistant Sales Manager of the Kellogg Switchboard and Supply Company, Chicago, Ill. His initial work in his new position will be aiding independent companies in co-ordinating their telephone expansion programs. Mr. Talmage had been with TVA for 16 years, where he directed construction of one of the largest power-line carrier systems in the world. He also spent seven years as a member of the staff of the Illinois Telephone Association, where engineering studies were made in more than 200 telephone exchange areas. Now serving on the Carrier Current Committee, Mr. Talmage acted as Chairman of East Tennessee Section.

H. A. Travers (A '41), Consultant on calculating board, relay, and system studies, has retired after 43 years with the Westinghouse Electric Corporation, East Pittsburgh, Pa. Under his leadership, 15 d-c and and 16 a-c calculating boards were designed for solution of problems concerning electric systems. Receiving his electrical engineering degree from Cornell University in 1906, Mr. Travers enrolled in the Westinghouse student training course. Afterward, he served as Switchboard Engineer until 1918. During the next nine years, he did technical advisory work for the Switchgear Division. At the end of this time, he was appointed to the position which he held on his retirement. Under Mr. Travers' leadership, the first Westinghouse a-c calculating board was built in 1929 for general use by the company and for rentals to utilities. In 1941, he received the organization's Order of Merit "for . . . . his pioneering work in the development of the network calculator."

R. A. Hopkins (A '19, M '35), Vice-President of the AIEE Pacific District, has retired from his post of Supervisor of Central Station and Transportation Sales, Westinghouse Electric Corporation, Los Angeles, Calif. He is succeeded by **C. V. Roseberry** (A '47), formerly Assistant District Central Station Manager with headquarters at San Francisco. A graduate of Stanford University, Mr. Hopkins joined Westinghouse in 1907 as a student apprentice at their East Pittsburgh, Pa., works. In 1910, he was transferred to the company's Los Angeles office, specializing largely in engineering and sales work with the petroleum industry in southern California. He was named Supervisor of Central Station and Transportation Sales in 1924. Secretary of the Los Angeles Section, 1923–24, and its Chairman, 1925–26, Mr. Hopkins served on the Membership Committee, 1943–45. His other society affiliations include: the Los Angeles Engineering Council of Founder Societies; the Los Angeles Electric Club; and the Pacific Coast Electrical Association.

E. A. Walker (A '34, F '47), Head of the Department of Electrical Engineering and Director of the Ordnance Research Laboratory at the The Pennsylvania State College, State College, Pa., is now on leave of absence to serve as Deputy Chairman of the National Research Council's Undersea Warfare Weapons Panel. In this position, he will make a study of the Navy's preparedness to meet the possible threat of enemy submarines. During the war, he was Associate Director of the Harvard Underwater Sound Laboratory, and in 1948, he received the Presidential Certificate of Merit for his work in the development of acoustic torpedoes. Mr. Walker has been a member of the AIEE Committee on Research since 1947 and a member of the Committee on Education since 1945.

L. T. Blaisdell (A '20, F '39), Commercial Vice-President of the General Electric Company, engaged in customer relations work with headquarters in Cleveland, Ohio, has been presented with a certificate signed by Charles E. Wilson, G-E President, and E. E. Potter, company Vice-President in charge of customer relations, in recognition of his 45 years of service with the company. With General Electric since his graduation from the Massachusetts Nautical Training School in 1904, Mr. Blaisdell was elected a commercial vice-president in 1936. He was assigned to the staff of Charles E. Wilson and customer relations activities in 1945.

G. D. Atkinson, Jr., (A '41), electrical engineer at Shasta Dam, has been named Superintendent of Operations at Shasta and its power plant and of Keswick Dam and power plant. These major features of the Central Valley project are located near Redding, Calif. Mr. Atkinson was first employed by the Bureau of Reclamation in 1930. Subsequently, he held various utility and government engineering positions. For the last two years, he has been in charge of installation of electric equipment at Shasta and Keswick power plants.

H. F. McRell (A '25), formerly Manager of Sales, has been named Assistant to the Manager of the Transformer and Allied Product Divisions, General Electric Company, Pittsfield, Mass. Other appointments were: **F. E. Fairman, Jr.** (M '41), Manager of Sales for the divisions; **W. S. Ginn** (A '37 M '49), Assistant Manager of Sales; and **C. E. Sutton, Jr.** (A '39, M '45), Manager of the Power Transformer Sales Divisions. Mr. Fairman previously was Assistant Manager of Sales for the Switchgear Division; Mr. Ginn was Manager of the Power Transformer Sales Division; and Mr. Sutton was Assistant Manager of the latter division.

J. H. Kuhlman (A '18, M '27), Professor of Electrical Design at the University of Minnesota, Minneapolis, has taken leave of absence from the university in order to teach for one year at the Instituto de Electrotecnica de São Paulo, at São Paulo, Brazil. His duties will begin this coming March. Professor Kuhlman, who does consulting engineering work for the Minneapolis-Honeywell Company and D. W. Onan and Sons, has served as Counselor of the Minnesota Branch since 1924, as well as Chairman of the District 5 Student Activities Committee and Chairman of the Minnesota Section.

J. W. Campbell (M '39), Outside Plant Engineer, American Telephone and Telegraph Company, New York, N. Y., retired recently. Mr. Campbell had been on loan to the Office of Military Government of Germany since 1948. Stationed at Frankfurt, he had been serving as Deputy Communications Chief of the combined United States–United Kingdom Zones. Mr. Campbell joined the Bell System in 1906 as an electrician with the New York and New Jersey Telephone Company. Transferred to the American Telephone and Telegraph Company in 1916, he was named Plant Practices Engineer in 1925 and Outside Plant Engineer in 1939.

H. T. Killingsworth (A '23, M '30) was recently elected a Vice-President of the American Telephone and Telegraph Company, New York, N. Y., and has been designated to succeed **F. R. Kappel** (M '43) as head of the Long Lines Department. Mr. Killingsworth was formerly General Manager of that group. Mr. Kappel becomes Vice-President in Charge of Operations and Engineering, filling the post previously held by **C. F. Craig** (M '27). Mr. Craig has been named Vice-President in Charge of Finance and will also continue to be responsible for rate and revenue matters.

H. J. Klumb (A '16) has been named Superintendent of the newly formed Department of Electric Operations and Planning of the Rochester (N. Y.) Gas and Electric Corporation. **G. H. Fiedler** (M '47) has become Superintendent of Electric Distribution and **H. A. Brown** (A '43), Assistant Superintendent of Distribution. Recently, Mr. Klumb was presented the annual award plaque of the Radio Fall Meeting, sponsored jointly by the engineering department of the Radio Manufacturers Association and the Institute of Radio Engineers, in recognition of "20 years of hard work for the Annual Fall Meeting." Mr. Fiedler is serving on the AIEE Insulated Conductors Committee.

A. R. Collard (A '36) has been named Manager of Substation Operation Department of the Consolidated Edison Company of New York (N. Y.), Inc. He succeeded **G. L. Sutherland** (A '20, F '27), retired. Mr. Collard joined the New York Edison Company in 1920. Before his new appointment, he was Superintendent of the Water Gas Division at Hunts Point. Mr. Sutherland retired last December after 21 years of service with Consolidated and predecessor companies. He is a former member of the AIEE Board of Examiners.

R. G. Slauer (A '41, M '48), Manager of the Applications Laboratory, Sylvania Electric Products Inc., Salem, Mass., has been elected to the grade of Fellow in the Illuminating Engineering Society in recognition of his outstanding work for the society and and the art of illumination. At present he is active on the society's six national committees: the Publications Committee; Coordinating Committee for Defense; National Technical Conference; Lighting Study Projects in Industry, Progress, and Street and Highway Lighting. He joined the staff of Sylvania Electric in 1944 after serving as Technical Director of the Westinghouse Lighting Institute. At present, he is serving on the AIEE Committee on the Production and Application of Light.

R. H. Halpenny (A '07, F '42, Member for Life) has been named Vice-President and Executive Engineer of the California Electric Power Company, Riverside. He has been Chief Engineer of the company since 1942. **W. B. Loper** (M '42) appointed Chief Engineer, has been succeeded as Assistant Executive Engineer by **W. T. Johnson** (A '39), former General Superintendent. **H. E. Pangborn** (A '48) has been moved up from Assistant General Superintendent to General Superintendent. Mr. Halpenny, whose new duties will include co-ordination of the company's engineering, operating, and construction activities, joined the firm in 1910.

F. M. Winterhalter (A '45), until recently Assistant Chief Engineer, has been named Engineer-in-Charge of A-C Design with the Allis-Chalmers Manufacturing Company, Milwaukee, Wis. Other new appointments are: **E. K. Spooner** (A '44), formerly a Supervisor in the Engineering Department, to Insulation Engineer; **I. C. Smith** (A '30, M '46), previously Development Engineer at Crocker-Wheeler Electric Manufacturing Company, Montclair, N. J., to Mechanical Engineer; and **W. T. Saveland** (A '37) to Assistant Mechanical Engineer.

F. P. Taugher (A '35, M '44), who since 1943 has been Engineering and Service Manager of the New England District of the Westinghouse Electric Corporation with headquarters in Boston, Mass., has been appointed Manager of Engineering in Westinghouse's Industrial Control Division at Buffalo, N. Y. Mr. Taugher is succeeded in Boston by **M. L. Gardner** (A '40, M '46), whose last post was Engineering Manager for the District Engineering and Service Department at East Pittsburgh, Pa.

E. F. W. Alexanderson (A '04, F '20, Member for Life), Consulting Engineer of the General Electric Company and inventor of the high-frequency alternator, recently was honored in Schenectady, N. Y. A plaque was unveiled on the anniversary of the first practical use of his invention—the sending of President Woodrow Wilson's "Fourteen Points" to Germany at the close of World War I. A 1944 Edison Medalist, Dr. Alexanderson is a Past-President of the Institute of Radio Engineers.

H. H. Weber (A '27, F '40) has been named General Sales Manager, Electrical Wire and Cable Department, United States Rubber Company, New York, N. Y. Sales Manager of the Wire and Cable Department since 1941, Mr. Weber joined the company 15 years ago. In the same department, **C. H. Le Vee** (M '42) was made Eastern Division Sales Manager with headquarters in New York, and **D. B. Karlskind** (A '46) has become Southwestern Division Sales Manager at Dallas, Tex.

V. H. Braunig (A '30, M '42) until recently General Superintendent of the Electric Department, City Public Service Board, San Antonio, Tex., has been promoted to General Manager. Two other appointments made at the same time were: **R. J. Foley** (A '30, M '46) to Mr. Braunig's former position; and **O. W. Sommers** (M '46) to the position of Executive Assistant to the General Manager. Mr. Braunig has been with the San Antonio utility for 39 years, Mr. Foley, since 1928, and Mr. Sommers, since 1929.

Roy Martindale (M '21, F '40), Assistant Chief Electrical Engineer in the Los Angeles (Calif.) Department of Water and Power since 1944, has retired. He had been with the department for over 37 years, beginning as a draftsman in 1911. Mr. Martindale had been the department's representative on the California Power Interchange Committee and was head of the Power Division from 1944 to 1946. Since the latter date, he had been conducting studies on the California river problem.

L. M. Smith (M '36) has been elected General Manager and **E. C. Easter** (A '46) has been named Vice-President in Charge of Sales for the Alabama Power Company, Birmingham. Mr. Smith, Vice-President since 1945 and elected a Director last year, joined the utility's Engineering Department in 1923 as a draftsman. Mr. Easter, who has been Sales Manager since last April, became associated with the company in 1924.

F. M. Feiker (M '34, F '42), Dean of the School of Engineering, George Washington University, Washington, D. C., has been given the Washington Society of Engineers' award, presented only three times in the 44 years of the group's existence. At one time, Dean Feiker served as assistant to Secretary of Commerce Herbert Hoover.

A. H. Lamb (A '35, M '44) has been appointed Vice-President of the Weston Electrical Instrument Corporation, Newark, N. J. Employed by the company since 1924, he will assume responsibility for the operation of the firm's Tagliabue Division. When the C. J. Tagliabue Corporation was purchased by Weston in 1948, Mr. Lamb was designated Acting Chief Engineer of the newly acquired affiliate, and at the same time was named Assistant Chief Engineer of the Weston organization.

L. E. Fisher (A '36, M '38) has joined the W. H. D. Hinchman Company, Detroit, Mich., as an associate. Formerly Chief Engineer with the Howell Electric Motors Company at Howell, Mich., Mr. Fisher, in his new position, will do consulting and professional electrical engineering work. In addition to these duties, he is a professor, teaching a-c machinery and symmetrical components, at the Lawrence Institute of Technology.

Bernard Lester (A '06, M '13, Member for Life), formerly Assistant Manager of Industrial Sales at the Westinghouse Electric Corporation, John A. Silver, and Frank W. Hankins have announced the formation of the management engineering firm of Lester, Hankins and Silver. The company has offices in Philadelphia, Pa., and New York, N. Y. Most recently, Mr. Lester has been acting as management consultant to a number of equipment manufacturers. He is a former chairman of the Fractional Horsepower Committee of the National Electrical Manufacturers Association.

David Sarnoff (M '23), Chairman of the Board, Radio Corporation of America, New York, N. Y., has been awarded a United Nations Citation for his helping "in the development of public understanding of the work of the United Nations and for his contribution in the field of human rights through advocacy of concepts of Freedom to Listen and Freedom to Look as fundamental expressions of Freedom of Information."

Charles E. Hickey (A '20), Manager of the Outside Plant Construction Department of the Consolidated Edison Company of New York, N. Y., has retired after 41 years of service with the company. He started with the New York Edison Company in 1905 as a Meter Tester and joined Consolidated Edison in 1937 as Manager of the Distribution Operation Department.

B. O. Haun, Jr. (A '38, M '45) has been named Field Engineer for newly formed territory of the Spencer Thermostat Division of the Metals and Controls Corporation; his headquarters will be in Dayton, Ohio. **Jerome Ottmar** (A '49) has assumed the duties of Sales Promotion Manager of Spencer, in addition to managing the Automotive and Aircraft Section of the division.

B. A. Case (A '30, M '44) has been promoted from Assistant to the Manager of Engineering to the post of Manager of Engineering, Small Apparatus Divisions, General Electric Company, Schenectady, N. Y. At the same time, **C. W. LaPierre** (A '28, M '43) was advanced from Assistant Manager to Manager of the Aircraft Gas Turbine Division. **E. E. Johnson** (A '25, F '47) is now Manager of Engineering, Large Apparatus Divisions.

M. W. Smith (A '20, F '42), President of the Baldwin Locomotive Works, Philadelphia, Pa., has been elected a Director of the Westinghouse Electric Corporation. Mr. Smith was elected Executive Vice-President of Baldwin in August 1948, when arrangements were made for Westinghouse to purchase 500,000 shares of Baldwin common stock. He succeeded to the presidency of the company in May of last year. For 33 years before becoming a Baldwin executive, Mr. Smith had been employed by Westinghouse.

Richard Cutts, Jr. (A '29) has been named Manager of Sales for the Central Station Divisions of the General Electric Company's Apparatus Department, with headquarters in Schenectady, N. Y. He will be succeeded as Assistant Manager of Sales for the Meter and Instrument Divisions at Lynn, Mass., by **D. E. Craig** (A '45, M '49), who has been Manager of Sales for the Unit Substation Section of the Central Station Divisions. Mr. Cutts has seen approximately 22 years service with General Electric; Mr. Craig became associated with the company in 1936.

L. F. Williams (A '27, M '47), Assistant Electrical Engineer for the Southern Pacific Company, San Francisco, Calif., has been advanced to Electrical Engineer. He succeeds **Paul Lebenbaum** (A '04, F '42, Member for Life), who retired recently. Filling Mr. Williams' previous post is **G. W. Kahler** (A '19), formerly Electrical Inspector. Mr. Lebenbaum is a member of the Land Transportation Committee of the AIEE.

A. R. van C. Warrington (A '31, F '49), Section Engineer at the General Electric Company's Switchgear Divisions, Philadelphia, Pa., since 1928, and a specialist in distance relaying, has been made Engineer in charge of meters and instruments for the English Electric Company, Stafford, England. His successor at General Electric will be **H. T. Seeley** (A '27), with the company since 1922. Mr. Warrington joined General Electric in 1925 at the Schenectady, N. Y., works.

E. D. Bent (A '42), former Assistant Chief Engineer of the Wire and Cable Division, Northern Electric Company Limited, Montreal, Quebec, Canada, has been promoted to Chief Engineer. He joined the company's Wire and Cable Laboratory in 1929. Currently, he is a member of the AIEE Committee on Insulated Conductors.

R. A Rugge (A'30, M'36) has been appointed Chief Engineer of Lear, Inc., Grand Rapids, Mich. Previously, he was Head of the Electrical Design and Development Departments of the Airplane Division of the Curtiss-Wright Corporation at Columbus, Ohio. Mr. Rugge is now serving on the Committee on Air Transportation.

W. E. Darrow (A '18, M '25), formerly in the Systems Development Department, Bell Telephone Laboratories, New York, N. Y., has retired. Mr. Darrow joined the New York Telephone Company in 1911, transferring to the American Telephone and Telegraph Company in 1919.

E. F. Leahey (A '12, Member for Life), Electrical Engineer in Charge of the Water System Electrical Division, Department of Water and Power, Los Angeles, Calif., has retired after 40 years of service to enter the real estate business. Mr. Leahey, with the Department since 1909, was transferred to the Los Angeles District in 1929, after acting as Foreman and Superintendent on several construction projects.

Herbert Hoover (HM '29), only living ex-President of the United States, was presented a plaque by the National Society of Professional Engineers at its recent meeting in Houston, Tex., in recognition of "a lifetime of devoted service to his fellow men and the welfare of his country and his profession."

E. S. Neighbours (A '46) has been appointed Superintendent of the Electrical Department, Birmingham (Ala.) Electric Company. He succeeds **A. G. Morton** (A '46), who has been made Consultant. Mr. Neighbours has been with the company since 1927, Mr. Morton since 1901.

Vannevar Bush (A '15, F '24, HM '49) has been elected a Director of Merck and Company, Rahway, N. J. Dr. Bush is President of the Carnegie Institution of Washington, D. C., and a Director of the American Telephone and Telegraph Company.

F. W. Funk (M '18) has been elected a Vice-President of the Ohio Edison Company, Akron. For the past 18 years, he has been Chief Engineer and in charge of the company's Production and Transmission Department.

F. B. Powers (M '37), formerly Assistant Vice-President, Production, of the American Car and Foundry Company, has been appointed Director of Manufacturing Operations of Federal Telephone and Radio Corporation, Newark, N. J. Previously he also served as Vice-President in Charge of Engineering for the Baldwin Locomotive Works in Philadelphia.

R. S. Glasgow (A '20, F '48), former Chairman of the Department of Electrical Engineering, Washington University, St. Louis, Mo., has been named Academic Dean of the United States Naval Postgraduate School, Annapolis, Md.

W. H. Cahoon (M '40), formerly with the Tennessee Valley Authority and more recently with the Vern E. Alden Company, Chicago, Ill., has joined the staff of the Fargo Engineering Company, Jackson, Mich.

R. W. King (M '35), Assistant to the President, Bell Telephone Laboratories, New York, N. Y., retired recently at his own request.

H. G. Burd (A '22) has been elected a Vice-President of the Ansonia Electrical Company, Ansonia, Conn. Mr. Burd has been associated with the Standard Underground Cable Company, the National Conduit and Cable Company, and since 1930 with the Anaconda Wire and Cable Company at Hastings-on-Hudson, N. Y.

L. A. Nelson (A '31, M '40), formerly of the Gould-Farmer Company, Syracuse, N. Y., has been named General Manager of the M. H. Salmon Electric Company in the same city. Mr. Nelson had been associated with Gould-Farmer, apparatus agents for the General Electric Company, since 1941.

Erling Frisch (M '49), formerly Manager of the Compressed Air Circuit Breaker Section, Westinghouse Electric Corporation, East Pittsburgh, Pa., has been appointed Manager of Control Engineering in the company's Atomic Power Division. Mr. Firsch has been with Westinghouse since 1923.

H. A. Holmes (A '14, F '39), Planning Engineer of the Monongahela Power Company, Fairmont, W. Va., and one-time head of the old Operating and Engineering Department, has retired after completing more than 26 years with Monongahela and predecessor companies. Prior to 1923, Mr. Holmes had been associated with the Duquesne Light Company, Pittsburgh, Pa.

C. H. Hoper (M '47), formerly City Manager of Colorado Springs, Colo., has joined R. W. Beck and Associates with offices in Seattle, Wash., and in Columbus, Nebr. It is planned that Mr. Hoper will represent the company in Arizona, New Mexico, Colorado, and southern states.

C. T. Weller (A '20, M '21) has retired from the General Electric Company, Schenectady, N. Y., after 37 years of service. He will continue to be active in the engineering field as a consultant.

T. A. Daly (A '42, M '48), formerly Section Engineer in the Ordnance Department, has been appointed Engineering Manager in charge of all naval ordnance work of the Westinghouse Electric Corporation, Sharon, Pa.

H. V. Bozell (A '08, F '23, Member for Life), President of the General Telephone Corporation, New York, N. Y., has been elected President of the United States Independent Telephone Association.

Thomas Ingledow (M '41), Vice-President and Chief Engineer, British Columbia Electric Railway Company Limited, Vancouver, Canada, has been elected Vice-President for British Columbia of the Northwest Electric Light and Power Association.

H. F. Boe (M '30), who has headed the Manufacturing and Repair Division of the Westinghouse Electric Corporation, Pittsburgh, Pa., since 1938, is slated to retire. Mr. Boe, who first joined Westinghouse in 1903, was named Vice-President in 1942.

P. H. Chase (A '12, F '43, Member for Life), Chief Engineer at the Philadelphia (Pa.) Electric Company, has been elected a Vice-President of the United States National Committee of the International Electrotechnical Commission.

O. C. Stark (A '45) has been appointed General Sales Manager of Photoswitch, Inc., Cambridge, Mass., with headquarters in New York, N. Y. Mr. Stark had been associated with the Square D Company, Detroit, Mich., since 1930.

Chester Lichtenberg (A '05, F '49, Member for Life) has retired after more than 42 years of service with the General Electric Company. Located in Fort Wayne, Ind., Colonel Lichtenberg's most recent post was that of Administrator of the Product Quality Division.

A. F. Black, Jr., (A '46), Assistant Superintendent, Electrical Department, City of Martinsville, Va., has been appointed Superintendent of the department. Mr. Black held his former post for the last two years.

H. J. Muehleman (A '17, M '45), formerly Operating Engineer, Hydro-Electric Power Commission of Ontario, Toronto, has retired after over 35 years with the Commission.

W. E. Jacobsen (A '39, M '45) has been appointed Assistant Manager of the Federal and Marine Engineering Division, General Electric Company, Schenectady, N. Y.

O. F. Metz (M '40) District Manager of the El Paso (Tex.) and Phoenix (Ariz.) offices of the Allis-Chalmers Manufacturing Company, has retired after nearly 43 years with the organization.

D. T. Shaw (A '45) has been named to the sales staff of Ferranti Electric Limited, Montreal, Quebec, Canada.

OBITUARY • • • • • •

Cornelius W. DeForest (A '07, M '21, F '36, Member for Life), former Chief Engineer with The Cincinnati (Ohio) Gas and Electric Company, died November 17, 1949, in Washington, D. C. At the time of his death, Mr. DeForest was acting as consultant to the Economic Co-operation Administration in regard to rebuilding the power supply facilities of the European countries included in the Marshall Plan. Born in Brooklyn, N. Y., September 19, 1878, Mr. DeForest entered the Meter Department of the Brooklyn Edison Company in 1894. In 1900, he joined the General Electric Company, Schenectady, N. Y., where he served in the Test Department and the Construction Department. Two years later, he was employed by the Union Light, Heat, and Power Company, Covington, Ky., as Master Mechanic; subsequently, he was made its Chief Engineer. Mr. DeForest became associated with the Union Gas and Electric Company of Cincinnati (a Columbia Gas and Electric Company subsidiary) in 1911. Later, he held the positions of Manager of the Electrical Department and Vice-President. Prior to 1935, he served as Vice-President in the Union Gas and Electric Company, the Columbia Power Company, and the Columbia Engineering and Management Corporation (all subsidiaries of the Columbia Gas and Electric Company). From 1935 until his retirement in 1944, he served the Cincinnati Gas and Electric Company as Chief Engineer. During his service in the Cincinnati electric system, Mr. DeForest helped in the design and construction of the West End Station and the Miami Fort Station in Cincinnati, and in the adding of superposed units in the Tait Station in Dayton, Ohio, the Miami Fort Station being the first central station in the world to be equipped initially for pulverized coal firing. The first hydrogen-cooled generator was installed at Tait Station. In 1945, the United States Army sent Mr. DeForest to Germany to investigate the extent of war damage to electrical facilities. Last year, he became technical adviser on all electric power projects coming under the Economic Co-operation Administration. He was a member of The American Society of Mechanical Engineers.

Rudolph Dueland (A '23, M '37), Sponsor Engineer, Ebasco International Corporation, New York, N. Y., died November 8, 1949, while in Havana, Cuba, on business. He was born in Haugesund, Norway, on July 30, 1896. He was graduated from the Oslo Technological Institute in 1919, and after being associated with the Westinghouse Electric and Manufacturing Company in Norway and with Metropolitan Vickers in Manchester, England, he came to the United States in 1923. His first position here was with the Electric Bond and Share Company, where he remained until 1933, holding various positions in the Engineering Department in connection with development of power station projects. In 1934, he became associated with Parsons, Clapp, Brinckerhoff, and Douglas as electrical engineer on a hydroelectric development in Nebraska. He remained in this position until he joined the Phoenix Engineering Company, New York, N. Y., in 1936 as Electrical Engineer. Two years later, he became identified with Ebasco as Electrical Engineer, later being designated Sponsor Engineer. During the war, he was Vice-Chairman of the Advisory Committee on Industry to the Royal Norwegian Ministry of Supply and Reconstruction in New York, and, in 1946, he was decorated with the Cross of Freedom by King Haakon VII for his services. After the war, he acted as Chairman of the Norwegian Industries Commission Advisory Council in New York. Mr. Dueland was a member of the New York State Society of Professional Engineers.

Remi Bollaert (A '38, M '48), Consulting and Application Engineer for the Westinghouse Electric Corporation, San Francisco, Calif., died December 2, 1949. Born in St. Boniface, Manitoba, Canada, on June 4, 1913, Mr. Bollaert was graduated from the University of California in 1936 with a Bachelor of Science degree, and received an Electrical Engineering degree from the same institution in 1937. After finishing college, Mr. Bollaert enrolled in the engineering student course at the East Pittsburgh (Pa.) works of the Westinghouse Electric Corporation, being transferred to the District Engineering Department at Los Angeles, Calif., in 1939. Three years later, he was designated Consulting and Application Engineer in the company's Engineering Department in San Francisco. There, his work was principally on industrial applications of all types of electric machinery, including motors and electronic equipment. An inventor of numerous control schemes for crane and electronic applications, he was engaged in work directly connected with the activities of the Armed Forces during World War II. Mr. Bollaert served on the Executive Committee of the San Francisco Section, 1948–49, and was elected Secretary of the Section for the 1949–50 term. He was a member of Eta Kappa Nu.

Louis E. Bogen (A '99, M '11, F '12, Member for Life), former engineer in the Motor and Generator Section of the Electrical Department of the Allis-Chalmers Manufacturing Company, Milwaukee, Wis., died December 3, 1949. He was born April 9, 1872 at Cincinnati, Ohio, and received the degree of Civil Engineer from the University of Cincinnati in 1894 and a Master of Science degree in electrical engineering in 1896 from Cornell University. A Professor of Physics at Ohio Mechanics Institute and at the University of Cincinnati before joining the Bullock Electric Manufacturing Company in Cincinnati in 1901, Mr. Bogen designed a-c and d-c machinery for the latter company. In 1903, he took charge of electrical estimating engineering and continued in this same work when Bullock was absorbed by Allis-Chalmers in 1904. Subsequently, Mr. Bogen transferred to the Allis-Chalmers Milwaukee works. In recent years, he had specialized in water-wheel generator and synchronous condenser applications, having participated in many of the world's pioneer hydroelectric installations. He retired in 1947.

Charles Everett Sisson (A '19, M '28, F '44), who lately had been appointed Field Secretary of the Engineering Institute of Canada, with headquarters at Toronto, Ontario, died recently. He had been associated with the Canadian General Electric Company from 1901 until last year. Born October 25, 1879, in Durham County, Ontario, he was graduated from the University of Toronto in applied science and engineering in 1905. While attending college he worked summers in the Test Department of the Canadian General Electric Company and was employed by that organization as Junior Designing Engineer at Peterborough, Ontario, from 1905 to 1911, and as Transformer Engineer in charge of transformer design during the following ten years. As Transformer Engineer, he was transferred to the firm's Davenport Works in Toronto in 1921. Eight years later, he was put in charge of all design engineering at Davenport in the capacity of Works Engineer. In 1942, he became Managing Engineer, directing all engineering and operations. A Vice-President of the Institute from 1929 to 1931, Mr. Sisson served as Chairman of the Toronto Section, 1927–28, on the the Electrochemistry and Electrometallurgy Committee, 1929–31, and on the Electric Machinery Committee, 1935–36. He was a member of the Engineering Institute of Canada and the Professional Engineers of Ontario.

Eugene Howard Austin (M '42), who had been with the Design Division of the Engineering Department, E. I. du Pont de Nemours and Company, Inc., Wilmington, Del., since 1934, died September 13, 1949. A native of Lewisburg, Pa., born January 24, 1890, he received an electrical engineering degree from Lehigh University in 1912. Prior to his association with du Pont, Mr. Austin had been identified with the Public Service Electric Company of New Jersey, the Panama Canal Commission in Panama, the Bell Telephone Company of Pennsylvania, and the Lehigh Valley Coal Company. Some of the design projects on which Mr. Austin worked at du Pont dealt with generating equipment, a pigment plant, mercury-arc-rectifier installations, and a large synthetic rubber plant.

Daniel Alexander McKenzie (A '15, M '20), Meter and Relay Engineer, Operations Division, Hydro-Electric Power Commission of Ontario, Toronto, Canada, died recently. He had been identified with the Commission since 1913. Born in Bridgen, Ontario, June 1, 1888, he received the degree of Bachelor of Applied Science in electrical engineering from the University of Toronto in 1912. In the same year, he was employed by the Toronto and Niagara Power Company. Subsequently, he joined the Hydro-Electric Power Commission of Ontario, accepting a post in the Operating Department, where he was in charge of power measurements and relay protection. He also directed all field testing of equipment. Mr. McKenzie served on the Protective Devices Committee, 1919–20, and as Chairman of the Toronto Section, 1930–31.

Albert Russell Zimmer (A '12, M '38, Member for Life) Professor of Electrical Engineering at the University of Toronto, Ontario, Canada, died November 11, 1949. Born in Cranbrook, Ontario, May 24, 1888, Professor Zimmer received the diploma of the School of Practical Science at the University of Toronto in 1907. After one year with the Canadian Westinghouse Company at Hamilton, Ontario, he returned to the University of Toronto to obtain the degree of Bachelor of Applied Science. In 1909, he joined the staff of the university's electrical engineering department as a demonstrator. Four years later, he advanced to the post of Lecturer. He became Assistant Professor of Electrical Engineering in 1921, Associate Professor in 1928, and was designated Professor in 1940. During the 1946–47 session he was acting head of the department. Professor Zimmer served as Chairman of the Toronto Section, 1946–47, and was a member of the Education Committee, 1944–48.

John Finlaw (A '35), Plant Superintendent, Schuylkill Station, Philadelphia (Pa.) Electric Company, died November 8, 1949. Born January 3, 1895, in Philadelphia, Mr. Finlaw had been identified with the Philadelphia Electric Company since 1912, when he joined the utility as an assistant station operator. He served on the Power Generation Committee, 1948–49, and was a member of the Engineers Club of Philadelphia. He had also been associated with the Pennsylvania Electric Association.

Herbert G. McAfferty (A '36), Sales Engineer with the Joslyn Pacific Company, Pasadena, Calif., died November 16, 1949. Born March 18, 1889, in Lake Geneva, Wis., Mr. McAfferty had been a representative of the company (formerly called the Joslyn Company of California) for the last 25 years. He was a member of the Electric Club of Los Angeles and the Pacific Coast Electrical Association.

MEMBERSHIP • • • •

Recommended for Transfer

The board of examiners at its meeting of December 15, 1949, recommended the following members for transfer to the grade of membership indicated. Any objections to these transfers should be filed at once with the Secretary of the Institute. A statement of valid reasons for such objections must be furnished and will be treated as confidential.

To Grade of Fellow

Gerszonowicz, S., elec. engg. prof.; director of electrotechnic inst., Univ. of Montevideo, Uruguay
Moses, G. L., mgr., dev. insulation sec., Westinghouse Elec. Corp., East Pittsburgh, Pa.

2 to grade of Fellow

To Grade of Member

Brackett, R. D., charge, export apparatus, loco & car equip. div., General Elec. Co., Erie, Pa.
Bray, F. E., Jr., marine elec. draftsman, Sun Shipbuilding & Drydock Co., Chester, Pa.
Brinker, C. S., senior engr., engg. & serv. div., Westinghouse Elec. Corp., St. Louis, Mo.
Carson, J. B., pres., Kingsport Elec. Co., Inc., Kingsport, Tenn.
Crabtree, J. W., engr., Knoxville Utilities Board, Knoxville, Tenn.
Cramer, J. H. A., elec. engr., Bauman Elec. & Neon Co., El Paso, Tex.
Fahrner, T., research engr., aerophysics lab., North American Aviation, Los Angeles, Calif.
FitzSimmons, L. G., Jr., member, technical staff, Bell Tel. Labs., Inc., New York, N. Y.
Forrest, E. F., asst. div. engr., General Elec. Co., Philadelphia, Pa.
Fritz, D. E., mgr., special aircraft projects, Jack & Heintz Precision Industries, Cleveland, Ohio
Fry, S., research lab analyst "a", Boeing Airplane Co., Seattle, Wash.
Gilson, R. M., elec. engr., Union Switch & Signal Co., Pittsburgh, Pa.
Hall, R. V., distribution engr., Pacific Gas & Elec. Co., Fresno, Calif.
Harris, L. D., assoc. prof. of elec. engg., University of Utah, Salt Lake City, Utah
Hatch, S. S., chief test engr., AC Spark Plug Div., GMC., Milwaukee, Wis.
Heidbreder, J. F., design engr., Westinghouse Elec. Corp., East Pittsburgh, Pa.
Hilden, W. C., engr., General Elec. Co., West Lynn, Mass.
Hughes, H. R., asst. area engr., General Elec. Co., Richland, Wash.
Jenner, J. W., pres. & mgr., Shelley Elec. Co., Wichita, Kans.
Kern, R. E. (Miss), dev. engr., General Elec. Co., Philadelphia, Pa.
Knights, K. R., asst. technical engr., The Hydro-Electric Power Commission of Ontario, Toronto, Ontario, Canada
Kramer, L. A., asst. prof. of elec. engg., Purdue University, Lafayette, Ind.
Kuenning, R. W., elec. engr., General Electric Co., Schenectady, N. Y.
Landwehr, I. H., project engr., Union Electric Co. of Missouri, St. Louis, Mo.
Lichtenfels, I. W., requisition engr., General Electric Co., Erie, Pa.
Mohan, A. R., chief engr., Sind-Cement Works, Rohri, Pakistan, India
Monroe, G. R., elec. engr., Westinghouse Electric Corp., Sharon, Pa.
Oseroff, D. M., design engr., Singmaster & Breyer, New York, N. Y.
Peairs, M. H., engr., Douglas Aircraft Co., Santa Monica, Calif.
Reynolds, N. E., engr., The Chesapeake & Potomac Tel. Co. of Baltimore City, Baltimore, Md.
Saunders, H. O., engr., Illinois Bell Tel. Co., Chicago, Ill.
Seal, P. M., asst. prof. of elec. engg., University of Maine, Orono, Maine
Stone, L. N., asst. prof. of elec. engg., Oregon State College, Corvallis, Oreg.
Storm, J. E., engg. squad leader, Parsons, Brinkerhoff, Hall & MacDonald, New York, N. Y.
Templeton, A. S., southeast mgr., Midland Constructors Inc., Miami, Fla.
Thomas, W. W., Jr., dev. engr., Sun Electric Corp., Chicago, Ill.
Thompson, A. C., acting supt. of power operations, Denver Federal Center, Denver, Colo.
Willson, W. G., mgr., Westinghouse Elec. Corp., Phoenix, Ariz.

38 to grade of Member

Applications for Election

Applications for admission or re-election to Institute membership, in the grades of Fellow and Member, have been received from the following candidates, and any member objecting to election should so notify the Secretary before February 25, 1950, or April 25, 1950, if the applicant resides outside of the United States, Canada, or Mexico.

To Grade of Member

Aun, C. C., Perak River Hydro-Elec. Power Co., Ltd., Ipoh, Malaya
Bagnall, W. R., Knappen, Tibbetts, Abbett Engg. Co., San Francisco, Calif.
Beck, L. A., Sr., Peterson Co., Denver, Colo.
Benthall, C. T., 757 E. Palm St., Altadena, Calif.
Buttner, H. R., Burndy Engg. Co., Bronx, N. Y.
Clipsham, W. B., Saskatchewan Power Corp., Regina, Saskatchewan, Canada
Dengler, K., Chesapeake & Potomac Tel. Co., Washington, D. C.
Doyal, G. M., Gulf Power Co., Pensacola, Fla.
Elliott, L. (re-election), Ebasco Services, Inc., New York, N. Y.
Geyger, W. A., Naval Ordnance Lab., Silver Spring, Md.
Hewit, H. O., Canadian Westinghouse Co., Ltd., New Toronto, Ontario, Canada
Keith, R. S., U. S. Rubber Co., Dallas, Tex.
Levine, S., Edo Corp., College Point, N. Y.
Loren, H. W., Westinghouse Elec. Corp., Tacoma, Wash.
Matyas, J. F., Natl. Advisory Comm. for Aeronautics, Cleveland, Ohio
Maxim, W., Natl. Advisory Comm. for Aeronautics, Cleveland, Ohio
Meister, J. B., Commonwealth Edison Co., Chicago, Ill.
Miller, J. A., Haughton Elevator Co., Philadelphia, Pa.
Morrison, W. K., Aluminum Co. of America, Massena, N. Y.
Ono, K. G., Intl. Harvester Co., Chicago, Ill.
Rector, R. V., General Elec. Co., Syracuse, N. Y.
Ridd, J. M., Automatic Elec. Co., Chicago, Ill.
Tendick, J. P., Westinghouse Elec. Supply Co., Duluth, Minn.
Van Duzer, R. M., Jr., The Detroit Edison Co., Detroit, Mich.
Walton, R. E., Continental Elec. Co., Gary, Ind.
Wickens, S. M., Columbus & Southern Ohio Elec. Co., Columbus, Ohio

26 to grade of Member

OF CURRENT INTEREST

Outstanding Electrical Engineers for 1949 Named by Eta Kappa Nu; Cheek is First

Outstanding young electrical engineers of the United States in 1949 will be recognized and presented awards by the Eta Kappa Nu Association in New York, N. Y., on January 30, 1950, during the week of the Winter General Meeting of the AIEE. The award winners are: winner—Robert Chase Cheek(M'47), Central Station Engineer, Westinghouse Electric Corporation, East Pittsburgh, Pa.; honorable mention—Dr. Lester M. Field, Associate Professor of Electrical Engineering, Stanford University; honorable mention—Louis G. Gitzendanner (M '49), Section Engineer, General Engineering and Consulting Laboratory, General Electric Company, Schenectady, N. Y. (Biographies of Mr. Cheek and Mr. Gitzendanner will appear in the March issue of *Electrical Engineering*.)

Presentation of awards will be made at a dinner meeting of Eta Kappa Nu in the Henry Hudson Hotel, 353 West 57th Street, New York, N. Y., at which the scheduled toastmaster is C. A. Powel (F '41), Massachusetts Institute of Technology, and the principal speaker is Dr. A. S. Adams, President of New Hampshire University.

The awards were established in 1936 by Eta Kappa Nu, national honorary electrical engineering fraternity, to recognize young electrical engineers for "meritorious service in the interest of their fellow men." The achievements that are considered in making selections include professional achievement, what the young engineer has done for his community, state, or nation, and how he has demonstrated his cultural development. Candidates are nominated by Sections of the AIEE, by faculty members of engineering colleges, and by key men in the industry.

The name of each award winner is engraved on a bronze bowl which is on public display in the headquarters of the AIEE, New York, N. Y. Each recipient of the award is presented with a miniature replica of the bowl. Honorable mention winners are presented with certificates.

To qualify for the award, the candidate must be not older than 35 years nor be out of college for more than ten years by May 1 of the year for which he is cited. After qualifying on these two counts the candidate is judged on the basis of accomplishment in professional, social, and cultural fields. Final selection of candidates is made by a jury of awards composed of well-known engineers from industry and educational institutions. In 1949, the Jury of Awards included: J. H. Foote (F '32), Vice-President, Commonwealth Services, Inc.; N. S. Hibshman (F '41), Dean, School of Science and Technology, Pratt Institute; W. B. Kouwenhoven (F '34), Dean, School of Engineering, Johns Hopkins University; C. A. Powel (F '41), Massachusetts Institute of Technology and Westinghouse Electric Corporation; R. W. Wilbraham, Chief Electrical Engineer, United Engineers and Constructors, Inc.

Eta Kappa Nu Award Goes to Illinois Tech

Winner of the Eta Kappa Nu Achievement Award for 1948–49 is the Delta Chapter of the Illinois Institute of Technology. The award is presented annually to the most outstanding of the honor society's college chapters. Shown (from left to right) are: George A. Schlosser, Student member AIEE, President of the Delta Chapter during the fall semester, 1949–50; James H. Kogen, Student member AIEE, President of the chapter for the spring semester, 1949; Eric T. B. Gross (F '48), Faculty Adviser to the chapter; and Edward F. Koncel, Student member AIEE, AIEE Fortescue Fellow for 1949–50, chapter President during the fall semester, 1948–49. This is the third time the Delta Chapter has received the Achievement Award. The plaques on the table were awarded to the Illinois Tech Chapter for the academic years, 1939–40 and 1947–48

American Standards Association Appoints Three New Directors

The American Standards Association announces election of three new members of its Board of Directors effective January 1, 1950, for a term of three years. Maurice Stanley, Chairman of the Board of the Fafnir Bearing Company, represents the Anti-Friction Bearing Manufacturers Association, Inc.; B. S. Voorhees, Vice-President of the New York Central System, represents the Association of American Railroads; and Colonel J. G. Vincent, Vice-President, Packard Motor Car Company, is the representative for the Automobile Manufacturers Association.

In addition, E. E. Potter, Vice-President of the General Electric Company, has been named by the National Electrical Manufacturers Association to fill out the unexpired term of Clarence L. Collens, who has just retired as Chairman of the Reliance Electric and Engineering Company. Miss Ardenia Chapman, Dean of the College of Home Economics, Drexel Institute of Technology, Philadelphia, is completing the unexpired term of Mrs. Carol Willis Moffett, well known for her work with the American Home Economics Association, as Member-at-Large.

Continuing on the board for another 3-year term are J. H. McElhinney, Vice-President of the Wheeling Steel Corporation, representing the American Iron and Steel Institute, and Auguste G. Pratt, Chairman of the Board of Babcock and Wilcox Company, representing the American Society of Mechanical Engineers. R. Oakley Kennedy, formerly Vice-President of Cluett, Peabody and Company, Inc., has been re-elected Member-at-Large for the next three years.

Engineering Curricula Accredited by ECPD as of October 28, 1949

Foreword. The Engineers' Council for Professional Development has as its objective the enhancement of the status of the engineering profession. To this end the Council inaugurated in 1932 a program dealing with the selection, guidance, training, and recognition of the members of the profession. The Council's Committee on Engineering Schools has as its initial objective the assisting in the improvement of the status of engineering education and "to formulate criteria for colleges of engineering which will insure to their graduates a sound educational background for practicing the engineering profession." To this end the undergraduate curricula of institutions rather than the institutions themselves are accredited, as it is recognized that curricula of different standards may sometimes be found in the same institution.

The purpose of accrediting is to identify those institutions which offer professional curricula in engineering worthy of recognition as such. Curricula is accredited on the basis of both qualitative and quantitative criteria and only those curricula which lead to degrees are accredited. Qualitative criteria are evaluated through visits of inspection by a committee or committees of qualified individuals representing ECPD. These criteria include such factors as the qualifications of the faculty, standards and quality of instruction, scholastic work of the students and their records as graduates, and the attitude and policy of the administration. Qualitative criteria, based upon requirements for admission and graduation, finances, enrollment, and the like, are evaluated through data from catalogs and questionnaires.

The wide acceptance of the committee's list by organizations such as the National Bureau of Engineering Registration, the National Council of State Boards of Engineering Examiners, by nearly all the individual state boards, by the professional engineering societies, several bureaus of the United States Government, and the institutions themselves, is evidence of the co-operation and respect of the institutions and organizations concerned.

In 1944 the ECPD appointed a Subcommittee on Technical Institutes to appraise curricula of the technical institute type, that is the area of education that lies between professional engineering on one side and vocational education on the other, such as technical institutes, junior colleges, evening sessions and extension divisions of colleges and universities, schools or training divisions associated with industries, specialized schools operated by government divisions, and correspondence schools. The curricula that were considered were technological in nature and lie in the post-high school area, differing in content and purpose from those of the vocational school on the one hand and the engineering college on the other.

The curricula are essentially technological based upon principles of science, require mathematics beyond high school, and emphasize rational processes rather than rules of practice; they are briefer, more intense, and more specific in purpose than collegiate engineering curricula, although they lie in the same general fields of industry and engineering. As in the case of the Committee of Engineering Schools, this subcommittee accredits the curricula rather than the institution and on a basis of both qualitative and quantitative criteria.

Both the Committee on Engineering Schools and the Subcommittee on Technical Institutes examine all types of engineering curricula, that is, mechanical, civil, chemical, and so on, as well as electrical. Inasmuch as the primary interest of AIEE members is in electrical engineering, only those institutions having accredited undergraduate electrical engineering curricula leading to a degree are contained in Table I. In Table II will be found those schools of the technical institute type which are accredited with curricula pertaining to electrical engineering or some phase thereof.

If further information is desired on the objectives and procedures of these committees together with a complete listing of all the accredited curricula given by the institutions, a pamphlet can be procured from the Engineers' Council for Professional Development, 29 West 39 Street, New York 18, N. Y. The cost is 25 cents.

Table I. Accredited Undergraduate Engineering Curricula

Akron, University of[c]
Alabama Polytechnic Institute
Alabama, University of
Arizona, University of
Arkansas, University of
Brooklyn, Polytechnic Institute of[a]
Brown University
Bucknell University
California Institute of Technology
California, University of[j]
Carnegie Institute of Technology[a]
Case Institute of Technology
Catholic University of America
Cincinnati, University of[c]
Clarkson College of Technology
Clemson Agricultural College
Colorado State College
Colorado, University of
Columbia University[b]
Connecticut, University of
Cooper Union School of Engineering[d]
Cornell University
Dartmouth College[i]
Delaware, University of
Denver, University of
Detroit, University of[c]
Drexel Institute of Technology[c-r]
Duke University
Fenn College[a,c-r]
Florida, University of
George Washington University
Georgia Institute of Technology[c r]
Harvard University[e]
Howard University
Idaho, University of
Illinois Institute of Technology
Illinois, University of
Iowa State College
Iowa, State University of
Johns Hopkins University
Kansas State College
Kansas, University of
Kentucky, University of
Lafayette College
Lehigh University
Louisiana Polytechnic Institute
Louisiana State University
Louisville, University of[c]
Maine, University of
Manhattan College
Marquette University[c-r]
Maryland, University of
Massachusetts Institute of Technology[c-r]
Michigan College of Mining and Technology
Michigan State College
Michigan, University of
Minnesota, University of
Mississippi State College
Missouri School of Mines and Metallurgy
Missouri, University of
Montana State College
Nebraska, University of
Nevada, University of
New Hampshire, University of
New Mexico College of Agriculture and Mechanic Arts
New Mexico, University of
New York, College of the City of[a]
New York University[a]
Newark College of Engineering[c-r]
North Carolina State College
North Dakota Agricultural College
North Dakota, University of
Northeastern University[c]
Northwestern University[c]
Norwich University
Notre Dame, University of
Ohio State University
Oklahoma Agricultural and Mechanical College
Oklahoma, University of
Oregon State College
Pennsylvania State College
Pennsylvania, University of
Pittsburgh, University of
Pratt Institute
Princeton University
Purdue University
Rensselaer Polytechnic Institute
Rhode Island State College
Rice Institute
Rose Polytechnic Institute
Rutgers University
Santa Clara, University of
South Carolina, University of
South Dakota State College
South Dakota School of Mines
Southern California, University of
Southern Methodist University[c]
Stanford University
Swarthmore College
Syracuse University
Tennessee, University of[c-r]
Texas, Agricultural and Mechanical College of
Texas Technological College
Texas, University of
Tufts College
Tulane University of Louisiana
Union College
United States Naval Postgraduate School
Utah, University of
Vanderbilt University
Vermont, University of
Villanova College
Virginia Military Institute
Virginia Polytechnic Institute
Virginia, University of
Washington, State College of
Washington University
Washington, University of
Wayne University
West Virginia University
Wisconsin, University of
Worcester Polytechnic Institute
Wyoming, University of
Yale University

Explanatory Notes

(*a*). Accrediting applies to day and evening curricula.
(*b*). Accrediting applies to the 4-year and 5-year curricula leading to the Bachelor of Science degree.
(*c*). Accrediting applies to the co-operative curriculum only.
(*c-r*). Accrediting applies to both the co-operative and regular curricula.
(*d*). Accrediting applies to the day and to 6-year evening curricula in the Cooper Union School of Engineering as submitted to ECPD.
(*e*). Accrediting applies only to curriculum as submitted to ECPD and upon completion of which a certificate is issued by Harvard University certifying that the student has pursued such a curriculum.
(*i*). These curricula extend over five years and terminate with the master's degree.
(*j*). Accreditation applies to both Berkeley and Los Angeles curricula.

Table II. Accredited Curricula of Technical Institute Type

Bliss Electrical School

Fundamentals of Industrial Electrical Engineering: A resident full-time program of instruction requiring 1,280 hours during a period of 32 weeks and leading to the award of a diploma upon successful completion.

Bridgeport Engineering Institute

A resident evening school program of instruction requiring 1,759 hours during a period of five years and leading to the award of a diploma upon successful completion.

Capitol Radio Engineering Institute

Residence Course in Practical Radio Engineering: A resident full-time program of instruction requiring a minimum of 1,200 hours during a period of 34 weeks. Under a system of individual progress the average time required to complete the work is 1,900 hours during a period of 60 weeks leading to the award of a diploma upon successful completion.

Correspondence Course in Practical Radio Engineering: A program of home study courses requiring from 1,200 to 2,400 hours to complete and leading to the award of a diploma upon successful completion determined by examination.

Central Radio and Television Schools

Basic Radio—Television: A resident full-time program of instruction requiring 2,020 hours during a period of 60 weeks and leading to the award of a diploma upon successful completion.

Franklin Technical Institute

Industrial Electricity: A resident full-time program of instruction requiring 2,040 hours during a period of 68 weeks and leading to the award of a certificate upon successful completion.

Milwaukee School of Engineering

Electrotechnician: A resident full-time program of instruction requiring 1,428 hours during a period of 48 weeks and leading to the award of a certificate upon successful completion.

Electronics Technician: A resident full-time program of instruction requiring 1,452 hours during a period of 48 weeks and leading to the award of a certificate upon successful completion.

Radio Technician: A resident full-time program of instruction requiring 1,452 hours during a period of 48 weeks and leading to the award of a certificate upon successful completion.

Oklahoma Institute of Technology (School of Technical Training—Division of Oklahoma A. & M. College)

Electrical Technician: A resident full-time program of instruction requiring 2,142 hours during a period of 72 weeks and leading to the award of a technician's certificate upon successful completion.

Radio and Electronics: A resident full-time program of instruction requiring 2,556 hours during a period of 72 weeks and leading to the award of a technician's certificate upon successful completion.

The Pennsylvania State College (Extension Service)

Industrial Electricity. An extension center full-time or part-time evening program of instruction requiring 960 hours during a period of 32 weeks for day instruction of a minimum of 160 weeks for evening instruction and leading to the award of an extension diploma upon successful completion.

Purdue University (Division of Technical Institutes)

Electrical Technology: An extension center full-time or part-time evening school program of instruction requiring 1,356 hours during a period of 72 weeks for day instruction or a minimum of five years of evening instruction and leading to the award of a technical institute diploma upon successful completion.

RCA Institutes

Advanced Technology Course (Radio Communication and Sound and Television): A resident full-time or evening school program of instruction requiring 2,320 hours during a period of 100 weeks for day instruction or 300 weeks for evening instruction and leading to the award of a certificate upon successful completion.

Southern Technical Institute (Division of The Georgia Institute of Technology)

Electrical Technology: A resident full-time or part-time evening school program of instruction requiring 1,826 hours during a period of 72 weeks for day instruction of a minimum of five years for evening instruction and leading to the award of a diploma upon successful completion.

Electronic and Radio Technology: A resident full-time or part-time evening school program of instruction requiring 1,848 hours during a period of 72 weeks for day instruction or a minimum of five years for evening instruction leading to the award of a diploma upon successful completion.

Spartan School of Aeronautics

Radio Engineering: A resident full-time program of instruction requiring 3,840 hours during a period of 96 weeks and leading to the award of a certificate of graduation upon successful completion.

Radio Technician: A resident full-time program of instruction requiring 1,920 hours during a period of 48 weeks and leading to the award of a certificate of graduation upon successful completion.

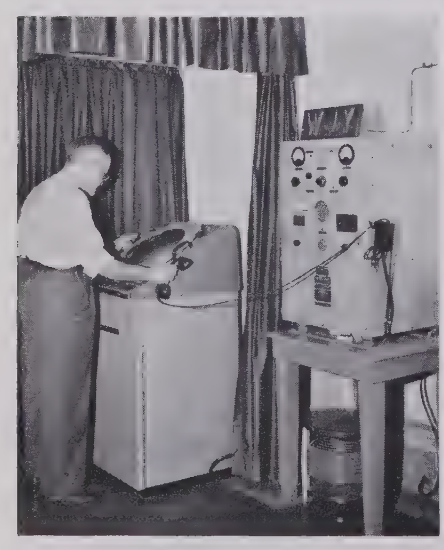
Wentworth Institute

Electrical Construction: A resident full-time program of instruction requiring 2,520 hours during a period of 72 weeks and leading to the award of a certificate upon successful completion.

Radar Equipment Installed in Baltimore Harbor to Aid Ships

Baltimore recently became the third major port in the world to put into operation a harbor radar system. The equipment will be used in a navigational aid research program designed to assist ships entering and leaving the port in fog and bad weather, to provide continuous observation of harbor shipping, and to give immediate information on the location of any shipping casualties in the harbor.

A marine radar unit provides port operators with a $12^1/_2$-inch radar chart of harbor shipping movements at ranges from 80 yards to 40 miles. It is installed at the City Recreation Pier in the radio control room, so that radar observations can be transmitted directly to harbor shipping over stations *WMH* and *WJY*, the city's ship-to-shore radio stations.



Standing at console, operator adjusts scope of Baltimore harbor's new radar unit

The radar, manufactured at the Wilkens Avenue plant of the Westinghouse Electronics and X-Ray Division, has been made available to the city on a long-term loan by the Division. The only other ports in the world equipped with radar are Long Beach, Calif., and Liverpool, England.

The radar unit consists of three major parts, one of which, the console, is located in the transmitter room. The antenna, protected by a large mushroom-like plastic dome, is located atop one of the radio towers, 140 feet above the water with the transmitter at the base of the tower. From this vantage point a maximum coverage of the harbor area is possible.

The radar scope picture is shown on the disk-like face of a $12^1/_2$-inch cathode-ray tube, mounted in the console. Water surfaces are dark while any objects—ships, buoys, shore lines, harbor buildings—are indicated in a bright fluorescent pattern. Thus, the harbor outlines appears as a continuous chart on the radar scope despite varying weather conditions. The radar operator has six ranges available—at one, two, four, eight, 20, and 40 miles—for uses varying from close inspection of the inner harbor up to an extensive view of the entire harbor.

A special feature of the equipment is an "electronic ruler"—an adjustable circle on the radar scope which can be set to measure and report the exact distance of objects from the pier with an accuracy better than one-tenth of a mile. This information relayed to a plotter enables him to establish the exact position of a vessel on a chart of the harbor. In addition, the radar observer can reference the position of the vessel to the radar presentation of buoys and prominent landmarks which define channel limits, turns, and anchorages.

The radar impulses sent out from the transmitter use a narrow beam and last for only one-quarter of a millionth of a second, making possible definition of ships close together, as well as allowing range measurements on ships at different distances from the pier but on the same bearing.

Although experience thus far has showed the feasibility of using radar to aid ships, a period of experimentation will precede actual use of the procedure during poor visibility. During this period radio operators will receive additional training, pilots will be made familiar with procedure, and the harbor will be checked for possible "blind spots" where large harbor installations block off the straight-line radar waves.

Shawinigan Power Builds 85-Mile Transmission Line

A new 85-mile transmission line, from La Tuque to Trois-Rivières, Quebec, Canada, has been put into operation a full year ahead of schedule and is now sharing the power load from Rapide Blanc and La Tuque generating stations to the Trois-Rivières terminal station, it was announced by James Wilson, president of The Shawinigan Water and Power Company, Montreal.

The line will be extended this year—also a year ahead of schedule—to Shawinigan's new Trenche generating station being built on the St. Maurice River 25 miles above La Tuque. When that plant goes into operation in 1951, the line will carry its preliminary load of 325,000 horsepower,

Future Meetings of Other Societies

American Institute of Mining and Metallurgical Engineers. Annual Meeting. February 12–16, 1950, Hotel Statler, New York, N. Y.

American Society for Testing Materials. February 27–March 2, 1950, William Penn Hotel, Pittsburgh, Pa.

American Society of Tool Engineers. Industrial Cost-Cutting Exposition. April 10–14, 1950, Convention Hall Buildings, Philadelphia, Pa.

Armed Forces Communications Association. 1950 Annual Meeting. May 12, 1950, New York, N. Y.; May 13, 1950, Fort Monmouth, N. J.

Institution of Electrical Engineers. Convention on Electric Railway Traction. March 20–23, 1950, London, England.

Midwest Power Conference. April 5–7, 1950, Sherman Hotel, Chicago, Ill.

National Association of Purchasing Agents. Midwinter Conference of the Public Utility Buyers' Group. February 13–14, 1950, Hotel Statler, Detroit, Mich.

National Electrical Manufacturers Association. March 13–16, 1950, Edgewater Beach Hotel, Chicago, Ill.

National Petroleum Association. April 12–14, 1950, Hotel Cleveland, Cleveland, Ohio

New Jersey Society of Professional Engineers. Annual Convention. April 14–15, 1950, Essex House, Newark, N. J.

Pennsylvania Electric Association. Joint Midwinter Meeting of the Prime Movers and Electrical Equipment Committees. February 23–24, 1950, Robert Treat Hotel, Newark, N. J.

Protective Relay Engineers. Third Annual Conference. March 20–22, 1950, Department of Electrical Engineering, Agricultural and Mechanical College of Texas, College Station, Tex.

Society of the Plastics Industry. Fourth National Plastics Exposition. March 28–31, 1950, Navy Pier, Chicago, Ill.

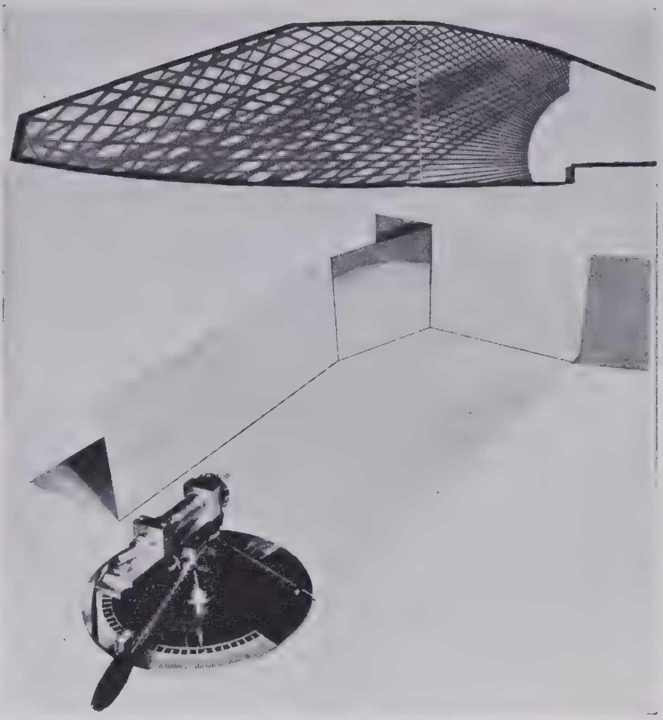
and ultimately, a load of 390,000 horsepower.

The new line, operating at 220,000 volts to the Trois-Rivières terminal, was built by the Shawinigan Engineering Company Limited, at a cost of about $3,000,000. It has 418 steel towers, from 81 to 157 feet high, connected by three aluminum conductor cables.

It is parallel to, and 100 feet from another line which runs from Rapide Blanc to Trois-Rivières, this proximity resulting in economies through savings on right-of-way costs, use of existing maintenance roads, and joint patrols for both lines.

To build the new line, about 1,000 acres of heavy bush had to be cleared. About 20,000 cubic yards of rock, earth, and muskeg had to be excavated by shovels or dynamite—all with great care to avoid damage to the existing power line.

MIT Students Use Light to Study Acoustics



Three Massachusetts Institute of Technology students have used the device shown below to predict acoustics of auditoriums. A beam of light from the projector in the foreground simulates sound coming from the auditorium stage. The light beam reflects off the vertical polished aluminum panels, which represent an auditorium ceiling and rear wall, in the same way sound would. Photographic paper on the flat surface in front of the panels records the results as the beam is moved to study sound starting in different directions from the stage. Above, a beam of light, reflected from the roof sections of a model auditorium has left its tracks on photographic paper, showing how sound from the stage at the right might reach its audience on the floor of the room, were a full-size auditorium built with the same ceiling shape. It was concluded from the study that an auditorium with a cross section like that shown would give best sound distribution. The three roof panels would reflect sound from the stage evenly across the entire floor, and the low rear wall would prevent serious echos

MIT Sloan Fellowships for 1950 Open to Business Executives

Fourteen young business executives, largest group in the 13-year history of the executive development program of the Massachusetts Institute of Technology, Cambridge, Mass., will be awarded Sloan Fellowships in 1950.

These fellowships, awarded to outstanding young executives in a nation-wide competition, cover a year of advanced study in economics and business administration at the institute and are aimed at preparing men for higher executive responsibility.

The fellows will be drawn from both large and small companies in various types of industry throughout the country. The winners of the fellowships will participate in a special program consisting of seminars, classes, and field investigations aimed not only at increasing technical managerial skill, but also at deepening their understanding of the social and economic implications of their work. They will study in the institute's departments of business and engineering administration and economics and social science, and will have an opportunity to conduct a special investigation in some selected field of industrial activity such as finance, production, or labor relations.

Applications for the awards must be made by February 24. Recipients will be selected on a competitive basis by MIT after consideration of the applicants' records and references, and consultation with their employers. Awards range up to $2,700 for single men and up to $3,700 for those who are married. Fellows will be in residence at the institute in Cambridge from June 9, 1950, to June 10, 1951. Applicants must be between the ages of 30 and 35 and have at least five years' industrial experience, part of it in an executive capacity. Candidates must be graduates with good academic records from an accredited college or university.

AEC Names Panels to Study Security, Declassifying of Data

Recommending data for declassification and examining security conditions are the jobs assigned to two panels recently appointed by the Atomic Energy Commission. The first of these groups, comprising representatives of engineering societies and the technical press, will study declassifiable information in the field of metallurgy, with a view to determining its possible value to American industry. Organization and functions of the AEC's Security Division will be surveyed by the other panel.

DECLASSIFICATION PROGRAM

Members of the data-declassification group have been given a complete security investigation and clearance to enable them to enter restricted areas and to examine restricted information files.

Members of the working party are: Keith Henney, Consulting Editor, *Nucleonics* and *Electronics*, and representative of the Institute of Radio Engineers; S. A. Tucker, The American Society of Mechanical Engineers; F. J. Van Antewerpen, Editor, *Chemical Engineering Progress*, American Institute of Chemical Engineers; Sidney Kirkpatrick, Vice-President, McGraw-Hill Book Company, Editor, *Chemical Engineering;* E. E. Thum,

Spraying Molten Steel at Westinghouse

One of the 50 engineers and technicians of the Westinghouse Electric Corporation's Manufacturing Engineering Department, East Pittsburgh, Pa., demonstrates the process of spraying molten steel. Worn equipment that would otherwise have to be discarded can now be repaired by utilizing this new technique that is still under test at the laboratory

American Society for Metals, Editor, *Metals Progress*.

Establishment of the working group is the second step in a trial program set up by AEC in response to the recommendation of its Industrial Advisory Group that information still classified, but potentially declassifiable and of special interest to industry, should be surveyed and declassified.

The first step of this program was taken with the appointment of a temporary advisory committee which met with AEC officials in September. At that time the advisory committee approved the general plan for the test program as proposed by AEC and nominated the members of the working party in the field of metallurgy.

The initial task before the working group will be to examine the abstract file maintained by the AEC Patent Branch. This file contains abstracts of technical subject matter on all novel, practical, and patentable processes and equipment developed in the atomic energy program. From selected groups of abstracts, the working group will decide which subject matter appears to be of interest to American industry generally, and complete reports of such subjects will be made available to the group for further consideration.

SECURITY SURVEY PANEL

The special panel on security, which is expected to require about two months for its task, will examine the Security Division's work in relation to other parts of the Atomic Energy Commission organization and activities. It will also advise the Commission on appointment of a new Director of Security and suggest possible candidates. The Director's post has been vacant since May 1949, when Admiral John Gingrich resigned to return to duty with the Navy.

The Security Division has responsibility for the physical protection of nation-wide AEC installations, the processing of personnel security clearances and the secure handling of classified documents and materials.

John S. Bugas, of Detroit, will be Chairman of the panel. Mr. Bugas is Vice-President of the Ford Motor Company in charge of industrial relations, and he was at one time agent-in-charge of the Detroit office of the Federal Bureau of Investigation.

Others who have accepted appointment to the panel are: Dr. John T. Tate, Chairman of the Physics Department, University of Minnesota, and J. Arthur Mullin, President, Glenvale Products, Detroit, Mich.

Irving Langmuir, G-E Scientist, Retires From Research Post

Dr. Irving Langmuir, one of the world's most noted scientists, has retired from the General Electric Company. Dr. Langmuir, who has been Associate Director of the company's Research Laboratory, Schenectady, N. Y., will continue his work in the laboratory in a consulting capacity. He will engage primarily in the activities of Project Cirrus, joint weather research program of the United States Army Signal Corps and the Office of Naval Research in consultation with the General Electric Company.

During his 40 years with General Electric, Dr. Langmuir made a substantial contribution to scientific knowledge. He did notable work on electron emission and gaseous discharges; his experimentation with oil films on water uncovered a new branch of chemistry, known as surface chemistry.

For his work, Dr. Langmuir has received the world's top scientific awards, including the Nobel Prize in chemistry, granted him in 1932.

The gas-filled incandescent lamp, the high-vacuum power tube, atomic hydrogen welding, a highly efficient smoke-screening generator for the military, and methods for artificial production of snow and rain from supercooled clouds are all products of Dr. Langmuir's researches.

Due recognition has been accorded Dr. Langmuir's achievements. He was twice awarded the Nichols Medal by the New York Section of the American Chemical Society (in 1915 and 1920). He received the Hughes Medal of the Royal Society of London in 1918; the Rumford Medal of the American Academy of Arts and Sciences in 1920; the Cannizaro Prize of the Royal Academy of Lincei, Rome, Italy, in 1925; the Perkins Medal in 1928; and the Chandler Medal and Willard Gibbs Medal in 1930.

In addition, he was presented the Franklin Medal of the Franklin Institute and the John Scott Award of the City of Philadelphia in 1937; the Faraday Medal of the British Institution of Electrical Engineers in 1944; and the Mascat Medal of the Société Française des Electriciens last year.

Dr. Langmuir was born in Brooklyn, N. Y., on January 31, 1881. He was graduated from Columbia University in 1903 with a degree in metallurgical engineering, and received Master of Arts and Doctor of Philosophy degrees from the University of Gottingen in Germany in 1906. Then, he became an instructor in chemistry at the Stevens Institute of Technology where he taught until July 1909. He next joined the staff of the General Electric Company's Research Laboratory.

The renowned scientist is a foreign member of the Royal Society of London, Past-President of the American Chemical Society, Past-President of the American Association for the Advancement of Science, and a Fellow of the American Physical Society. He is also a member of the Academy of Arts and Sciences, Tau Beta Pi, Sigma Xi, and an honorary member of the Chemical Society of London.

Irving Langmuir

$250,000 Electric Computer Unveiled at Northwestern

A quarter-of-a-million-dollar electronic computer, that can solve problems ranging from the design of automobile springs to intricate relations in the field of economics, has been unveiled at the Technological Institute of Northwestern University, Evanston, Ill.

Part of the big machine was built by the Westinghouse Electric Corporation, which constructed the first computer of this type. Engineers of Northwestern's Aerial Measurements laboratory designed most of the electronic components, all of which were built by Northwestern students. The computer is financed and owned by the Bureau of Aeronautics, United States Navy. Two years were required to bring the machine into service, and it is continually being improved as new problems arise.

Here is how the computer operates. A mechanical, economic, or some other system is represented through a group of equations by a mathematician and then plugged into the computer. The equations and the system thus are set up in electrical form on the computer in an analogue. Once the engineer has the system represented on the computer, he has only to turn dials to experiment with it. The results are observed in graphical form on an oscilloscope, which looks much like a television screen.

Occupying a room 22 by 55 feet, the big machine weighs more than ten tons. Twenty-five large cabinets, all of which can be interconnected to a main control desk, are needed to hold all the electronic devices which make up the computer. The room is air-conditioned so that the sensitive electronic elements will maintain the accuracy that is required during the solution of the problem on the computer.

MIT Gets Grants-in-Aid From Industry Totalling $800,000

Industrial grants-in-aid totalling $800,000 to the Massachusetts Institute of Technology have been announced by Dr. James R. Killian, Jr., President of the institute. The grants bring total gifts to the institute in its current development program to $6,526,914.02.

Grants announced included $250,000 from the United Fruit Company of Boston; $50,000 from an unnamed Massachusetts corporation; $250,000 from the Cities Service Research and Development Company of New York; and $250,000 from the Standard Oil Company of California.

The United Fruit grant, "to support the institute's program of research," is earmarked to be invested with endowment and other funds until the principal may be expended upon mutual agreement between the company and the institute, the income from invested funds to be allocated each year to fields jointly selected by the two parties.

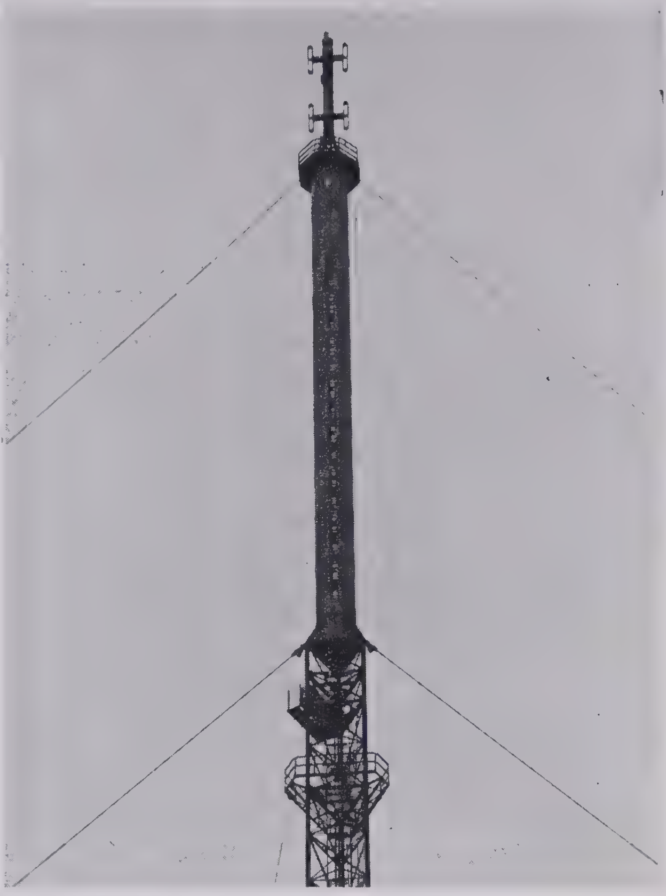
These fields include such projects as the Laboratory for Biology and Food Technology and the entire range of the institute's activities that are unclassified from the point of view of government security. Income from the fund may be applied to fellowships, operating expense, and other appropriate types of expenditures.

The Standard Oil Company of California specified that a "substantial part" of its grant be applied to chemical engineering and chemistry, nuclear science and engineering, and research projects in lubrication, friction, and wear and corrosion.

The Cities Service Research and Development Company grant sustaining MIT's current development program is to be applied to research and development work in the fields of nuclear physics and chemistry, mechanical engineering, and chemistry and chemical engineering. The grant is payable at the rate of $50,000 a year.

Britain's New 750-Foot Television Mast

At the top of Britain's new 750-foot-high television mast, located near Birmingham, is a short square tower carrying eight folded dipole aerials, arranged vertically in two groups of four, one above the other. The slotted section below can be used to radiate very-high - frequency sound programs. The mast's 140 tons weight is pivoted on a steel ball two inches in diameter. An electric elevator, fitted with "walkie-talkie" apparatus for communication with the ground, runs up to the platform seen at the bottom of the picture. From there upwards, the way is by "cat ladder" and step bolts



NBS Announces Revisions in Technical Broadcast Services

A new series of technical radio broadcast services over radio stations *WWV*, Beltsville, Md., and *WWVH*, Maui, Territory of Hawaii, were inaugurated on January 1, 1950. Except in certain details, these services of the National Bureau of Standards will not differ greatly from those given in the past.

The revised services from *WWV* include: (1) standard radio frequencies of 2.5, 5, 10, 15, 20, 25, 30, and 35 megacycles; (2) time announcements at 5-minute intervals by voice and International Morse Code, (3) standard time intervals of one second, and one, four, and five minutes; (4) standard audio frequencies of 440 cycles (the standard musical pitch A above middle C) and 600 cycles; (5) radio propagation disturbance warnings by International Morse Code consisting of the letters *W*, *U*, or *N*, indicating warning, unstable conditions, or normal, respectively.

The audio frequencies are interrupted at precisely one minute before the hour and are resumed precisely on the hour and each five minutes thereafter. Code announcements are in Universal Time using the 24-hour system beginning with 0000 at midnight; voice announcements are in Eastern Standard Time. The audio frequencies are transmitted alternately: The 600-cycle tone starts precisely on the hour and every ten minutes thereafter, continuing for four minutes; the 440-cycle tone starts precisely five minutes after the hour and every ten minutes thereafter, continuing for four minutes. Each carrier frequency is modulated by a seconds pulse which is heard as a faint tick; the pulse at the beginning of the last second of each minute is omitted.

Radio station *WWVH*, recently established in Hawaii by the National Bureau of Standards, broadcasts on an experimental basis on 5, 10, and 15 megacycles. The program of broadcasts on the three frequencies is essentially the same as that of station *WWV*. Reception reports indicate that *WWVH* is received at many locations not served by *WWV*, thus extending the area served by standard frequencies and time signals. Time announcements in Universal Time are given from *WWVH* every five minutes by International Morse Code only.

Further information on the technical radio-broadcast services may be obtained on request from the National Bureau of Standards, Washington 25, D. C.

Hoover and Jester Honored at Meeting of NSPE and TSPE

In parallel conventions held in Houston, December 8–10, 1949, the National Society of Professional Engineers and the Texas Society of Professional Engineers bestowed their highest honors, respectively, to Ex-President Herbert Hoover (HM '29) and to the late Governor Beauford H. Jester.

The NSPE paid tribute to Mr. Hoover as "engineer, statesman, and humanitarian," and presented its first distinguished engineer award to Mr. Hoover at its annual banquet.

The TSPE presented a hand-lettered scroll to the family of the late Governor, in which Mr. Jester was praised for his far-sighted policy in appointing professional engineers to 25 positions of responsibility in State affairs.

Alan G. Stanford of Atlanta, Ga., president of the National Society, made the presentation of the NSPE's bronze plaque, bearing the engraved image of Mr. Hoover and its tribute to him, to Jesse H. Jones of Houston, former member of the President's cabinet. Mr. Jones, who was one of the original directors appointed by Mr. Hoover to the Reconstruction Finance Corporation, had been chosen by Mr. Hoover to accept the plaque for him. Because of his duties as chairman of the commission to reorganize the executive branch of the government, Mr. Hoover was unable to attend.

The Hoover award was made at the final banquet of the two societies at the Rice Hotel crystal ballroom. Entertainment features of the convention included a cocktail party at the Shamrock Hotel, a boat trip down to the Houston Ship Channel, dinner at San Jacinto Inn adjoining the famous San Jacinto Battlefield, and what was reported to be a highly humorous men's style show in the Empire Room of the Rice Hotel under the auspices of the ladies of the convention.

Westinghouse Supplies Equipment for New Brazilian Power Project

An agreement covering the first phase of Brazil's new Paulo Afonso power project on the Sao Francisco river has been concluded between the Companhia Hidro-Eletrica do Sao Francisco and the Westinghouse Electric International Company. The agreement calls for the supply of $4,209,000 of electric and mechanical equipment, including two 60,000-kw generators, water wheels, valves, transformers, head gates, and Tainter gates.

The apparatus will be installed in the first of five power stations at Paulo Afonso Falls in northeastern Brazil, 149 miles by air from the Atlantic. Each of these stations will have an ultimate capacity of 180,000 kw to be shared by the states of Alagoas, Sergipe, Bahia, Pernambuco, and Pariaba. Energy from the two 60,000-kw generating units covered by the present agreement will be transmitted over high-voltage lines to three coastal cities—by a north line 206 miles to Recife, an east line 112 miles to Propria, and a south line 203 miles to Salvador. The station covered by the present agreement is scheduled for completion in early 1952.

The Paulo Afonso project is part of a larger development program for the Sao Francisco valley. The river provides one of the main means of internal transportation, running north and east about 2,000 miles. Throughout this vast region the Brazilian government plans to carry out flood control, irrigation, rural electrification, and industrial and agricultural development based on the pattern which was used by the Tennessee Valley Authority.

Tau Beta Pi Fellowships. Approximately seven $1,200 fellowships are being offered by Tau Beta Pi for the school year 1950–51. All members of the honor society who are college seniors or graduates are eligible. These fellowships may be used in any branch of the engineering field—professional practice, teaching, or research. Candidates must be single, or, if married, must be able to prove that their financial status would be the same as if single. Deadline for submission of applications is February 28, 1950. Awards will be announced March 31. Application forms may be obtained from Paul H. Robbins, Director of Fellowships, 1121 15th Street, N.W., Washington 5, D. C.

Louisiana Engineering Society Meets. The Louisiana Engineering Society of which H. L. Lehman is president held its 1950 Annual Meeting at the St. Charles Hotel in New Orleans on January 12, 13, and 14. Technical sessions at the meeting were sponsored by the local chapters of the various engineering societies and institutes of Chemical, Electrical, Illuminating, Heating and Ventilating, Refrigerating, Military, Civil, Mining and Metallurgical, Mechanical, Geologic, and Plastic Engineers. Those attending included engineering students from Tulane University, Louisiana State University, Louisiana Polytechnic Institute, and Southwestern Louisiana Institute. Technical exhibits, industrial plant visits, a harbor trip, a general interest session at night, and a banquet and ball featured the meeting. Special arrangements for entertainment of the ladies were made by the Women's Auxiliary of the Louisiana Engineering Society.

SAM Awards Gilbreth Medal to J. K. Louden, York Official

James Keith Louden, Vice-President and Assistant to the President of York Corporation, York, Pa., was presented with the Gilbreth Award for his contributions to the advancement of scientific management on the evening of November 3 at the annual banquet of the Society for Advancement of Management, Hotel Statler, New York, N. Y.

The citation for Mr. Louden's award read in part: "James Keith Louden . . . is awarded the Gilbreth Medal for 1949 for his outstanding contributions to the advancement of the science of management, and specifically for the inception and organization of a comprehensive industrial engineering department in one of our large and progressive industries; for his leadership as president of the Society for Advancement of Management; . . for his inauguration of an Annual Time Study and Methods Conference jointly sponsored by the Society for Advancement of Management and The American Society of Mechanical Engineers."

Mr. Louden was national president of the Society for Advancement of Management in 1941–42, and as a past-president, holds an honorary life membership in the society. Before joining York Corporation in 1948, he was associated with Armstrong Cork Company in Lancaster, Pa. Mr. Louden is also a member of The American Society of Mechanical Engineers, is Chairman of the Management Division, and is their representative to the National Management Council.

First Annual Arizona Convention of Engineering Societies Held

The first combined convention of Arizona engineering societies was held in Phoenix, Ariz., last November 18 and 19. Participating organizations were the AIEE, the American Society of Civil Engineers, The American Society of Mechanical Engineers, and the newly chartered Arizona Society of Professional Engineers.

On the evening of November 18, 125 members of the four societies heard a speech on "Economics for the Engineer" delivered by Joseph S. Thompson (F '38), President of the Pacific Electric Manufacturing Corporation, San Francisco, Calif. Among others who spoke at the banquet was W. B. Bustard (M '42), Chairman of the AIEE Arizona Section.

The following day, the four societies split up into their respective sections. Approximately 85 persons attended the AIEE luncheon, after which they heard an address on "Television Comes to Phoenix" by Walter J. Stiles, Chief Engineer of *KPHO-TV*. Subsequently, the group was taken on a conducted tour of that station. All 85 made the inspection trip.

At its section meeting, the Arizona Society of Professional Engineers received its charter from Orland C. Mayer, Vice-President of the National Society of Professional Engineers, who represented Allen G. Stanford, President of the organization.

The civil engineers heard technical papers on the design of the Queen Creek Bridge, on recent developments in sanitation, and on engineering valuation. A round table discussion on manufacturing problems in Arizona featured the ASME meeting.

Navy Wind Tunnel at MIT Simulates Speeds of 3,000 Mph

Now ready for supersonic research is one of the largest wind tunnels to be operated by a university. Housed at the Naval Supersonic Laboratory of the Massachusetts Institute of Technology, the tunnel is designed to produce speeds ranging from 1.2 to 4 times that of sound, the high figure being equivalent to 3,000 miles per hour.

Recent dedication ceremonies for the wind tunnel marked completion of the Naval Supersonic Laboratory, the facilities of which will be used to test scale models of supersonic missiles and for research to obtain basic aeroballistic information. Wind tunnel studies will help make possible design improvements in high-speed missiles and aircraft.

The test section of the new wind tunnel, where models are studied in a high-speed air-stream, measures 18 by 24 inches. By changing the density of the air passing through the test section, conditions at high altitudes encountered in flight can be dupliciated. The wind tunnel is a huge closed steel channel, through which very dry air is circulated by two large centrifugal compressors driven by electric motors totalling 10,000 horsepower. Heat generated by the compressors is removed by two large coolers which use water from the nearby Charles River as the cooling medium.

Illinois Tech Offers Fellowships. Illinois Institute of Technology is now accepting applications for the 1950 Westinghouse fellowship in power systems engineering. An award of $1,500 and tuition for three semesters of full-time intensive training leading to a Master of Science degree in electrical engineering is made to the successful applicant. Candidates must have a bachelor's degree in electrical engineering from an accredited engineering college. The course of study includes both practical and theoretical training. It includes experience with the $90,000 A-C Network Calculator used in actual power systems studies for utility and manufacturing companies. Term of the fellowship will begin September 1950. Applications must be received by March 15. The winner will be announced April 1. Further information and application blanks may be obtained from the Dean of the Graduate School, Illinois Institute of Technology, Chicago 16.

Electrical Exposition in Kansas City. Exhibits depicting electrical developments during the past 100 years will be featured in the Exposition of Electrical Progress, to be held in Kansas City, Mo., March 8–12. In addition, nearly 200 booths will be rented to electrical companies who wish to demonstrate their products and services. The exposition, which is a part of the celebration honoring Kansas City's Centennial, is an annual event sponsored by the Exposition of Electrical Progress Association, in cooperation with the Electric Association of Kansas City. Inquiries and correspondence should be addressed to the Exposition of Electrical Progress Association at 106 West 14th Street, Kansas City 6, Mo.

Figgis Becomes Stevens Trustee. Dudley W. Figgis, president of the American Can Company, has been elected a vice-chairman of the Board of Trustees of Stevens Institute of Technology, Hoboken, N. J. Dr. Figgis was awarded the honorary degree of Doctor of Engineering by Stevens in 1948. Starting work with the American Can Company in 1902, he advanced through the sales department to finally become president of the company. He is now responsible for the operation of 68 plants in the United States, Hawaii, and Canada.

Minneapolis Engineering Societies Exposition. Dramatic demonstration of new equipment in all fields of engineering with the emphasis on live action will keynote the Fifth Annual Exposition of the Minnesota Federation of Engineering Societies which will be held at the Minneapolis Armory, Minneapolis, Minn., February 21–24, 1950. The guest register for previous years shows that interest in the exposition is not confined to Minnesota alone but attracts men interested in new tools and tool design from states as far west as Montana and the neighboring states of North and South Dakota, Wisconsin, and Iowa. Exhibitors will have an opportunity to show their latest educational films in the Little Theatre which has a seating capacity of 150. This service, which is free to all exhibitors, provides a 16-millimeter machine, screen, and operator.

NEMA Elects Officers. C. T. Lawson, Vice-President in Charge of Sales, Kelvinator Division, Nash-Kelvinator Corporation, Detroit, Mich., has been elected president of the National Electrical Manufacturers Association at the annual NEMA meeting, held in Atlantic City, N. J. He succeeds B. W. Clark, Vice-President in Charge of Sales of Westinghouse Electric Corporation, Pittsburgh, Pa. Elected Vice-Presidents were: C. W. Higbee, United States Rubber Company, New York, N. Y.; J. H. Jewell, Westinghouse Electric Corporation, Pittsburgh, Pa.; James F. Lincoln, The Lincoln Electric Company, Cleveland, Ohio; E. E. Potter, General Electric Company, New York, N. Y.; A. F. Sheldon, Kennecott Wire and Cable Company, Phillipsdale, R. I. At NEMA's annual luncheon, three of the electrical manufacturing industry's outstanding pioneers were honored at the annual luncheon through presentation of 50-year awards. They were: Claude L. Matthews, President of W. N. Matthews Corporation, St. Louis, Mo.; Charles E. Wilson, President of the General Electric Company, Schenectady, N. Y.; and Fay Woodmansee, President of the Engineers Equipment Company, Melrose Park, Ill.

McLaughlin Heads AIME. Donald H. McLaughlin, of San Francisco, Calif., has been elected President of the American Institute of Mining and Metallurgical Engineers for 1950. Dr. McLaughlin is President of the Homestake Mining Company. Two Vice-Presidents were also elected: Andrew Fletcher, President, St. Joseph Lead Company, New York, N. Y.; and Robert W. Thomas, General Manager, Nevada Consolidated Copper Corporation, Roy, Ariz. Five new Directors elected were: Harold Decker, Assistant Manager, Pan American Production Company and Pan American Gas Company, Houston, Tex.; Francis B. Foley, Superintendent of Research, The Midvale Company, Philadelphia; E. C. Meagher, Treasurer, Texas Gulf Sulphur Company, New York, N. Y.; Gail F. Moulton, Geologist, Department of Petroleum Economics, The Chase National Bank, New York, N. Y.; and Howard I. Young, President, American Zinc, Lead and Smelting Company, St. Louis, Mo.

NCSBEE Holds Annual Meeting. Clarence L. Eckel, Dean of Engineering at the University of Colorado, Boulder, was elected President of the National Council of State Boards of Engineering Examiners at its 28th Annual Meeting, held at Daytona Beach, Fla., November 10–12. Official delegates from 35 states and representatives appointed by ten national engineering societies attended. H. H. Henline, Secretary of AIEE, was the Institute's officially appointed representative. A number of committee reports were made at the meeting; in the Executive Secretary's report, it was indicated that there are now more than 150,000 registered professional engineers in the United States and Canada and that more than 11,500 Engineers-in-Training have been certified by 19 states. It was also pointed out that 16 states have amended their laws during the past two years, principally for the purpose of raising standards and making their laws more in accord with the Model Law.

RMA Establishes New TV Committee. Approval by the Board of Directors of the Radio Manufacturers Association of a plan for the immediate establishment of a National Television System Committee highlighted the recent 3-day RMA Fall Meeting. Accordingly, the RMA Television Committee was authorized to present to the Federal Communications Commission a plan for setting up the new committee. To be composed of top electronic and television engineers, the National Television System Committee will be charged with presenting technical data, relative to the allocation of ultrahigh frequencies and the lifting of the "freeze" on very-high-frequency allocations, and recommending basic standards for the future development of color television.

Welding Research Council Officers. At the recent annual meeting of the Welding Research Council held in New York, N. Y., Dr. C. A. Adams, who has been serving as the Chairman of the Council since its beginning, was elected its Honorary Chairman. H. C. Boardman, who has been serving as Vice-Chairman, was elected Chairman, and Dr. A. B. Kinzel was elected Vice-Chairman. Dr. Adams was the first President of the American Welding Society and the first Director of the American Bureau of Welding, which position he held until the Bureau was discharged and the Welding Research Council was organized under the Engineering Foundation in 1935. Mr. Boardman is Research Director of the Chicago Bridge and Iron Company, and an Honorary Member of the American Welding Society. Dr. Kinzel is President of the Union Carbide and Carbon Research Laboratories, Inc., and Past Chairman of the Engineering Foundation Board. The Welding Research Council was created at the request of the American Welding Society and AIEE to foster and stimulate co-operative research in the welding field, and to review and make readily available in condensed usable form the welding literature of the world. In 1946 the sponsorship of the Council was enlarged to include the American Society of Civil Engineers, the American Institute of Mining and Metallurgical Engineers, The American Society of Mechanical Engineers, and The Society of Naval Architects and Marine Engineers.

Textile Engineering Course Accredited. The Engineers' Council for Professional Development, official accrediting agency of the engineering profession, has given accreditation to the textile engineering course at the Georgia Institute of Technology at Atlanta. Prior to this year there have been no officially approved courses in textile engineering in the United States and Canada. Accreditation of the course was determined by an inspection committee which consisted of Professor F. K. Teichmann, New York University; Professor R. A. Morgan and Dr. A. F. Greaves-Walker, University of Florida; Dr. A. W. Murray and Dean E. B. Norris, Virginia Polytechnic Institute; Dean S. B. Earle, Clemson College; and Dean Fred J. Lewis, Vanderbilt University.

LETTERS TO THE EDITOR

INSTITUTE members and subscribers are invited to contribute to these columns expressions of opinion dealing with published articles, technical papers, or other subjects of general professional interest. While endeavoring to publish as many letters as possible, Electrical Engineering reserves the right to publish them in whole or in part or to reject them entirely. Statements in letters are expressly understood to be made by the writers. Publication here in no wise constitutes endorsement or recognition by the AIEE. All letters submitted for publication should be typewritten, double-spaced, not carbon copies. Any illustrations should be submitted in duplicate, one copy an inked drawing without lettering, the other lettered. Captions should be supplied for all illustrations.

Symbolic Nomenclature

To the Editor:

If Isaay Stempnitzky in his letter to the editor (*EE, Nov '49, pp 1016–7*), had carried his Case 1 discussion a little further he might not have concluded that the Case 2 identification is more profitable. Since the cross product is not commutative, the sign difficulty, which he mentions at the end of Case 1, can be avoided by standardizing the order of the factors to correspond to the sign of reactive power required by the Institute Standards.

The fact that the cross product results in a reactive power vector which is perpendicular to the voltage and current vectors is fortunate. The power sinusoid which can be represented by the "directed line" for reactive power (as Professor LePage so clearly sets forth in his article, *EE, Jul '49, pp 561–5*) has twice the frequency, or half the period, of the voltage and current sinusoids. The vector power (see Institute Standards) should therefore appear in some other plane than that in which the voltage and current "directed lines" are drawn. This will be the case if active power is plotted along the "real" axis and reactive power is plotted along the third axis, perpendicular to the plane of voltage and current.

These "directed lines," which are the graphical representation of complex numbers, may be manipulated in a third form of multiplication which, as Professor LePage points out, is not found in vector analysis. Thus, they may have most of the properties of "true vectors," plus at least one which is peculiarly their own.

Because of this latter fact, and also because the application of the cross product has not been emphasized, there is wide interest in a distinctive name for these lines. Several interesting ones have appeared in the article and correspondence cited. Mention was not made of an accurate and specific designation, "complexor," which has been used in at least one textbook ("Fundamentals of A-C Machines," Sah). This term seems somewhat cumbersome though it has one syllable less than either "complex number" or "directed line." It may well be shortened by dropping another syllable to become "plexor."

A scalar quantity can be designated by the distance between two specified points on one linear scale. A complex quantity can be designated by specified segments of two linear scales which intersect at right angles. Two points, properly located in the plane which is determined by the two scales, can indicate these two segments simultaneously. The line between these two points can be said to represent the complex number. Thus, a complex number or quantity can significantly be called a planar quantity, to distinguish it from a scalar quantity; its linear representation can be called a "planar." This descriptive and distinctive term is less radical than "plexor." Either of the two can be used to connote all of the properties associated with complex numbers.

A. A. NIMS (M '28)
(Department of Electrical Engineering, Newark College of Engineering, Newark, N. J.)

Leon Charles Thévenin

To the Editor:

With reference to the article, "Leon Charles Thévenin" (*EE, Oct '49, p 843–4*), I would like to point out that the "Thévenin theorem" was published as early as 1853 by H. Helmholtz in Poggendorff's *Amalen der Physik und Chemie* (page 211), four years before Thévenin was born.

On page 212 he first formulates the principle of superposition:

> If any system of conductors contains electromotive forces at various locations, the voltage (potential) at any point of the system will be equal to the algebraic sum of the voltages (potentials), which any one of the electromotive forces would produce at this point independent of the others.

Then he considers the case, where any two points of such a system (output terminals) are bridged with another conductor (load). He states, page 222, that no matter how complicated the system may be, it will behave with respect to the load as one single conductor of a resistance, as calculated between these two points by Kirchhof's rules, in series with an electromotive force, equal to the voltage between these two points before inserting the load.

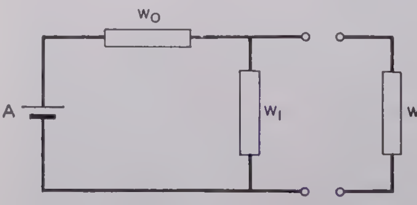


Figure 1

On page 223, he illustrates his theorem by the simple example (see Figure 1), where the system consists of two linear (lumped) conductors of resistance w_0 and w_1, in series with an electromotive force A. He then points out that, according to his theorem, the system with respect to a load w_2 can be replaced by an equivalent source, having the electromotive force

$$s=A\frac{w_1}{w_0+w_1}$$

and the interior resistance

$$w=\frac{w_0 . w_1}{w_0+w_1}$$

and consequently will drive a current in w_2

$$i_2=\frac{s}{w+w_2}$$

In my opinion, this is a very clear formulation of what is now called "Thévenin's theorem."

Helmholtz not only considered the case of a system of "linear conductors" (lumped resistances) but also the general case of a space, filled with resistive material of different conductivity, and electromotive forces acting in the resistive medium (distributed resistances). He then states, that if any two points at the surface of this space are connected by a load resistance, one can always replace the space by one lumped resistance in series with an electromotive force, and that this equivalent source will always drive the same current in the load as would the actual space source.

I personally have no objection to calling this theorem "Thévenin's theorem," although it is called "Helmholtz's theorem" in other countries, but it is quite interesting that it was considered "new" in 1883, 30 years after Helmholtz's publication.

H. F. MAYER
(Professor, School of Electrical Engineering, Cornell University, Ithaca, N. Y.)

To the Editor:

The recent article "Of What Value is History?" by I. E. Mouromtseff (*EE, Nov '49, pp 945–8*) was of great interest to me since I have felt for a long time that history of science is not only a very fascinating subject as such, but also of considerable help to the research engineer. Many a "new" invention or result is buried in the literature of the distant past.

Since the author mentions H. Helmholtz (1821–1894) as one of the greatest physicists of his time, it may be appropriate to point out that the "principle of the equivalent generator" (P.E.G.) which was first formulated by Helmholtz is widely known abroad under this name (P.E.G.), apparently because it was considered a minor contribution of this famous scientist.

Even if Thévenin did not know of this theorem when he wrote his article in 1883 and perhaps he should have known it, those who discovered Thévenin approximately a quarter of a century ago, would have found out from a study of the history of circuit theorems who originated what they then "named" Thévenin's theorem.

Thévenin published his very short paper, in 1883[1]; its first paragraph (of altogether five) was reprinted on page 844 of the October issue of *Electrical Engineering*. In his paper, he merely states the theorem of the equivalent generator without any proof whatsoever, and one will understand Vashy's impression, who was not very enthusiastic about this "discovery." Helmholtz published his paper in 1853, 30 years before Thévenin[2]; it is a comprehensive analytical investigation which contains the rigorous proof. Perhaps it should be appropriate to go back to the name "principle of the equivalent generator" which has been in use long before some poor students of the history of science discovered Thévenin.

REFERENCES

1. Sur un Nuveau Théorème d'Électricité Dynamique, **L. Thévenin.** *Comptes Rendus Hebdomadaires Des Séances De L'Académie Des Sciences*, tome 97, 1883, page 159.

2. Ueber Einige Gesetze der Vertheilung Elektrischer Stroeme in Koerperlichen Leitern mit Anwendung auf die Thierisch—Elektrischen Versuche, **H. Helmholtz.** *Annalen der Physik und Chemie*, band 89, 1853, S. 213 ff.

ERIC T. B. GROSS (F '48)

(Graduate School, Illinois Institute of Technology, Chicago, Ill.)

Circuit Calculations

To the Editor:

Electric circuit problems are seldom described by unique solutions. This is particularly true for networks comprising a plurality of power sources and power receiving stations.

These introductory words and the rest of this letter are essentially a part of the answer recently given to a group of students who brought up the question, "How can the flow of current and/or energy be traced from source to sink through electric networks?"

The objective of this letter is not at all an exposition or even an adequate exploration of this difficult problem. The writer does, however, think readers of *Electrical Engineering* may be interested in the introductory part of the discussion which he presented in a form he has not seen presented by any other person.

Reference is made to Figures 1 and 2 which illustrate a resistance R fed by two batteries supplying electromotive forces E_1 and E_2. In Figure 1 the two supplies are additive and in Figure 2 the voltage E_2 opposes that of E_1.

Since our electromotive forces sources are direct current selected for simplicity in illustration, we know for Figure 1 that if $I_1=3$ amperes and $I_2=4$ amperes, the current in $R=7$ amperes and the I^2R power input to resistance $R=49$ R watts. If this solution were unique, we would know that the two currents I_1 and I_2 coming together make a current I_3 with a value of 7 amperes.

It can be demonstrated on the other hand that we are equally justified in considering I_1 and I_2 as distinctly separate currents, each independently of the other, wending its way through resistance R. In this case the power in R in watts equals $(I_1+I_2)^2R$ which equals $(I_1^2+2I_1I_2+I_2^2)R$. Using the values noted, namely 3 amperes and 4 amperes, we have $(3+4)^2R$ or $(9+24+16)R=49$ R.

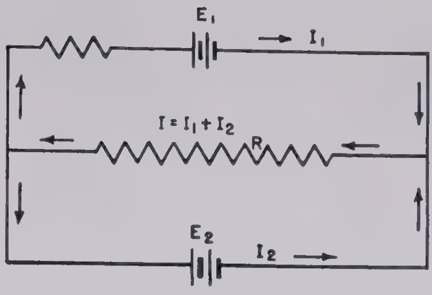


Figure 1. Currents I₁ and I₂ in same direction through resistance R

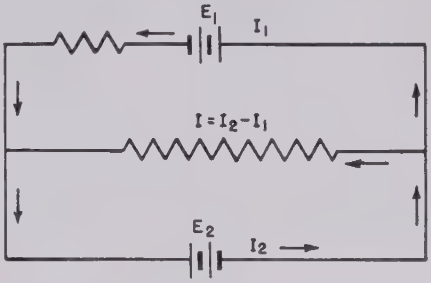


Figure 2. Current I₁ in direction opposite to current I₂ through resistance R

The same value as obtained by use of the more commonly used but less general 7^2R computation. In Figure 2 with the currents subtractive with respect to each other, we have power equals $(4-3)^2=(16-24+9)R=1$ R; thus by the algebraic solution checking the more commonly used arithmetic solution of the problem. Either analysis solves the problem correctly, and we may argue with equal weight that we have a single current of seven amperes the arithmetic sum of two currents or we may say that we have two distinct currents each circulating independently through R.

As one considers the philosophy of electric current flow it seems to the writer that the $(x+y)^2R$ algebraic method is the more logical and more general of the two even though its use is negligible as compared to the use of arithmetic method.

Since even this simple problem cannot be said to have a unique solution it seems unreasonable to think of any network as yielding only to a unique description of electric current and energy flow.

ROYAL W. SORENSEN (F '19)
(President AIEE 1940–41, Professor of Electrical Engineering, California Institute of Technology, Pasadena, Calif.)

Electrostatic or Electromagnetically Induced Electric Field?

To the Editor:

"There seems then to be no unique and physically significant definition of the electrostatic part of an electric field observed in a limited region of space" . . . "There is but one electric field, **E**, and Maxwell, our prophet, has proclaimed its properties" . . . . "A resolution of a local field into an electrostatic part and an inductive part . . . must be irrelevant, and without intrinsic physical meaning."

Thus speaks Dr. J. Slepian, High Priest of Maxwell's theory (*EE, Nov '49, pp 985–7*).

There is but one physical meaning to the term "electric field intensity," **E**, at a point, namely that it gives, in magnitude and direction, the force experienced by a stationary unit electric charge situated at the point. However, experience shows that other measurable quantities can be related to the value of **E**, and I do not think that anyone has ever actually measured **E** by directly measuring the force on one unit point charge. As an important example of a related quantity, if in a homogeneous conductor of resistivity ρ a current-density $\mathbf{i}$ exists at any point, then experience with circuits leads us to accept the law:

$$\mathbf{E}=\mathbf{i}\rho \tag{1}$$

where **E** is the electric field intensity at the point.

Now the particular property of an electrostatic field, which distinguishes it from an electromagnetically induced electric field, is that it is derivable from a potential, and therefore its line-integral around a closed path is zero:

$$\oint \mathbf{E}_s\cdot d\mathbf{l}=0 \tag{2}$$

Consequently, between any two points there is a perfectly definite difference of potential, independent of the integration path between the points:

$$V_{ab}=\int_a^b \mathbf{E}_s\cdot d\mathbf{l} \tag{3}$$

and it is the function of many electromagnetic devices, such as the transformers manufactured by the company which employs Dr. Slepian, to produce potential differences between their terminals of accurately known magnitudes.

Let us therefore apply Dr. Slepian's doctrine to one of his company's transformers, with its secondary winding on open circuit. Since no secondary current is flowing, if **E** is the resultant, total, one and only Maxwellian electric field intensity at a point inside the copper of the secondary winding, we know, from equation 1, that:

$$\mathbf{E}=0 \tag{4}$$

Dr. Slepian teaches that it is immaterial as to whether we regard **E** as electrostatic or as electromagnetically induced, and further that it is meaningless to try to split it into two components. But we may be forgiven for wanting to know how many volts the transformer will provide, or in other words its terminal potential difference. Therefore, since potential difference is the line-integral of an electrostatic field, following Dr. Slepian we shall assume that **E** in equation 4 is electrostatic, and surely we can make no mistake if we take the line-integral from one secondary terminal to the other through the path of the winding which connects them. Hence we immediately obtain:

$$\text{Secondary terminal potential difference on open circuit}=\int_{T_1}^{T_2}\mathbf{E}\cdot d\mathbf{l}=0 \tag{5}$$

Thinking this result a little puzzling (for, after all, the transformers of Dr. Slepian's company are reputed to work), suppose we take the line-integral of the electrostatic field along a path between the terminals in air. But on second thought we give up this idea for we know that potential difference depends only on the terminal points, and not on the particular integration path, so we should still get zero potential difference.

If, on the other hand, we admit the existence of two components of electric field at the point in the secondary conductor, $\mathbf{E}_s$ which is electrostatic and $\mathbf{E}_i$ which is induced, we put:

$$\mathbf{E}=\mathbf{i}\rho=\mathbf{E}_s+\mathbf{E}_i=0 \tag{6}$$

or, on open circuit:

$$\mathbf{E}_s=-\mathbf{E}_i \tag{7}$$

Now potential difference has meaning only when applied to $\mathbf{E}_s$, so we have, for the terminal potential difference:

$$V=\int_{T_1}^{T_2}\mathbf{E}_s\cdot d\mathbf{l}=-\int_{T_1}^{T_2}\mathbf{E}_i\cdot d\mathbf{l}=-E \tag{8}$$

where E is the induced electromotive force, and the minus sign tells us that, if we move along the winding in the direction of fall of potential, we move in a direction opposite to that in which $\mathbf{E}_i$ (and E) act.

We can, of course, calculate V as a rise of potential between terminals, in which case we get, on open circuit:

$$V=E \tag{9}$$

or, if the transformer is loaded and I is the secondary current, from equation 6:

$$-\mathbf{E}_s=\mathbf{E}_i-\mathbf{i}\rho \tag{10}$$

which on integration along the winding gives:

$$V=E-IR \tag{11}$$

where of course E is the total electromagnetically induced electromotive force, due to both mutual and leakage fluxes.

Since Dr. Slepian apparently denies the relevance of all this, it would be most interesting to know his explanation of the terms potential difference (V) and induced electromotive force (E) as applied to electric circuits, and his definition of these measures in terms of the two "eternal equations."

E. G. CULLWICK (M '33)
(Professor of Electrical Engineering, St. Andrews University, Dundee, Scotland)

To the Editor:

Professor Cullwick misquotes me badly when he says that I "teach that it is immaterial as to whether we regard E as electrostatic or as electromagnetically induced." What I did say in my electrical essay was that the resolution of $\mathbf{E}$, the electric field in a given region in space which can be observed uniquely and locally by local operational means into an electrostatic part, $\mathbf{E}_s$, and an electromagnetically induced part $\mathbf{E}_T$, $\mathbf{E}=\mathbf{E}_s+\mathbf{E}_T$, does not have any unique significance, and expresses no physically determinable reality. I did not say that we may regard any local field as all "electrostatic," meaning by "electrostatic" the quality of being the gradient of a scalar. Of course, fields exist which are not the gradients of scalars. But the resolution of such a field into the sum of a part which is the gradient of a scalar, and another part which is not can be done in infinitely many ways, and such resolution has no unique significance.

In his book, "Fundamentals of Electromagnetism," Macmillan, 1939, Professor Cullwick apparently defines the electrostatic component of the field at a point in space as that field which is calculated at that point from the Coulomb potentials of all the charges in the universe. The remaining part of the electric field at the point in question is then called magnetically induced.

Let us apply these definitions which I attribute to Professor Cullwick, I hope rightly, to the field outside a cavity oscillator, that is a completely enclosed metal container within which there is an oscillatory electromagnetic field. Let us assume that the net field, outside, which can be observed directly, without peering into the box, is zero; that is that any small charged body at rest there experiences no unbalanced mechanical force. Then, as I understand Professor Cullwick, he would say that this zero electric field outside the box, which obviously can have no observable electrical influence upon anything, is "really" made up of an "electrostatic" part, which Professor Cullwick can calculate from the charges inside the cavity oscillator, and a magically just equal and oppositely directed magnetically induced electric field which Professor Cullwick can cleverly also calculate from the varying magnetic fields inside the metal box.

Now, I am broad-minded and am perfectly willing to let Professor Cullwick, "for his real or imaginary convenience," assert that there are these equal but oppositely directed electric fields penetrating through the thick metal walls of the container and reaching outside, but I balk at regarding this resolution of the external zero field as having any unique or physically verifiable significance. I myself can resolve the actual zero field into equal and opposite components, in a thousand different ways, all of which are just as good as Professor Cullwick's as far as any physical test goes. However, I would regard that only as a manifestation of my own mathematical ability, and would not believe that these component fields had any verifiably unique reality. Similarly, the nearly zero electric field inside the metal conductor of the transformer coil to which Professor Cullwick refers, can be resolved by the designer into an induced field and an almost equal and opposite electrostatic field. I insist however, that this resolution is only for the designer's convenience, and reflects no demonstrable reality.

Replying to the specific questions in the last paragraph of Professor Cullwick's letter, I define the potential difference from one point to another in an electric field as the integral of the electric field, $\int\mathbf{E}_s ds$, along some path joining the two points, provided the field has a potential, which will not generally be the case, that is provided $\int\mathbf{E}_s ds$ is independent of which particular path is chosen in going from one point to the other. I define induced electromotive force only for closed paths and as $\int\mathbf{E}_s ds$ around such a closed path.

J. SLEPIAN (F '27)
(Westinghouse Research Laboratories, East Pittsburgh, Pa.)

Of What Value Is History?

To the Editor:

I enjoyed the recent article, "Of What Value Is History?" (*EE, Nov '49, pp 945–8*) very much. There is indeed much to be learned from the history of electrical engineering, and also from the psychological attitude of professional men toward any radically new trend of thought. It brings to mind an exceedingly mysterious case, as recent as 1944, in which a man and his work were completely ignored by all the technical journals—in spite of widespread articles in the semitechnical magazines. I refer to the researches of Dr. Felix Ehrenhaft. He claimed that the traditional belief that magnetic poles occur only in equal and opposite pairs is contrary to fact, and gave clear and explicit experimental procedures whereby this could be shown. One of the best articles on him appeared in *Popular Science*, June 1944.

It is not my intention to express any opinion whatsoever on the merits of Ehrenhaft's research. I only want to point out that he made what is, to electrical engineers, a fantastic claim; that he backed up his claims by completely adequate diagrams and directions whereby anyone could attempt to duplicate his work; and that as far as I have been able to determine not a single electrical engineer even took the trouble to publish a criticism of his work. For no understandable reason, all mention of Dr. Ehrenhaft ceased abruptly. The last article I could find appeared in *Science Digest*, issue of October 1944.

Does anyone know the real truth behind the "Ehrenhaft mystery?"

RICHARD M. KELSEY (A '47)
(319 Lincoln Avenue, Bridgeport, Conn.)

NEW BOOKS • • • • •

The following new books are among those recently received at the Engineering Societies Library. Unless otherwise specified, books listed have been presented by the publishers. The Institute assumes no responsibility for statements made in the following summaries, information for which is taken from the prefaces of the books in question.

INGENIEURE, BAUMEISTER EINER BESSEREN WELT. By F. Münzinger. Third edition. Springer-Verlag, Berlin/Göttingen, 1947. 263 pages, charts, tables, $8^1/_2$ by $5^3/_4$ inches, stiff cardboard, apply. The important topics dealt with are the relation between technology and the sociological aspects of civilization, and the contributions and obligations of the engineer to society. The author also discusses, among other things, the influence of engineering training on men, and follows the history of certain inventions with particular attention to their consequences. The book closes with a speculation on the hypothetical reaction of a resurrected member of a past generation to the current disturbed state of affairs.

INTRODUCTION TO THE ELECTRON THEORY OF METALS. (Institute of Metals Monograph and Report Series number 4). By G. V. Raynor. Institute of Metals, 4 Grosvenor Gardens, London, S.W.1, England, 1947. 98 pages, diagrams, charts, tables, $8^3/_4$ by $5^1/_2$ inches, cloth, 7s.6d. Written for the metallurgists who have not had recent training in physics, this text gives a picture of the development of the electron theory of metals. It outlines some of the ideas which lie behind the theory, and indicates its applications to physical metallurgy and the properties of metals.

KONTAKTUMFORMER MIT SCHALTDROSSELN. By A. Goldstein. Verlag AG. Gebr. Leeman and Company, Zürich, Switzerland, 1948. 179 pages illustrations, diagrams, charts, tables, $8^{3}/_{4}$ by 6 inches paper, 18, geheftet. Of interest to students and electrical engineers, this book describes a new type of rectifier which is a member of the mercury arc rectifier and rotating converter group. The fundamental principles of this rectifier are considered as well as the technique of switching which is used. Methods of regulation are explained.

PERSONNEL MANAGEMENT. By W. D. Scott, R. C. Clothier, and W. R. Spriegel. Fourth edition, McGraw-Hill Book Company, New York, N. Y.; Toronto, Ontario, Canada; London, England, 1949. 648 pages, illustrations, diagrams, charts, tables $9^{1}/_{4}$ by 6 inches, cloth, $4.50. Of value to students and businessmen, this revised edition presents a comprehensive outline of up-to-date principles, practices, and instruments in the important relationships between management and workers. The revision includes new chapters on the development of the union movement and on communicating with employees. Throughout the authors assume a mutual interest on the part of employer, employee, community, and government. One of the features is the description of the role played by psychology in the initial selection, transfer, and promotion of employees and in the realm of training, morale measurement, and development.

PITTSBURGH INTERNATIONAL CONFERENCE ON SURFACE REACTIONS. Corrosion Publishing Company, Pittsburgh 12, Pa., 1948. 236 pages, illustrations, diagrams, charts, tables, 11 by $8^{1}/_{2}$ inches, paper, $10; $6.50 to those attending conference. The meetings of this conference, which was intended to stimulate the exchange of scientific information, were organized around the following general subjects: theory of liquid phase reactions; theory of oxidation and surface reactions; preparation of surfaces; new methods and results; methods and results; fundamental mechanisms; and, corrosion and its measurement. Eleven of the 28 papers were presented by specialists from countries other than the United States. The conference was ponsored by seven national and regional organizations.

ROCKET PROPULSION ELEMENTS. By G. P. Sutton. John Wiley and Sons, New York, N. Y.; Chapman and Hall, Ltd., London, England, 1949. 294 pages, illustrations, diagrams, charts, tables, $8^{1}/_{2}$ by $5^{1}/_{2}$ inches, cloth, $4.50. Designed as a reference manual as well as a college text, this book presents both the basic elements and the technical problems of rocket propulsion systems. Emphasis is placed more on liquid propellant rockets rather than on solid propellant units, but the material on thermodynamic, thermochemical, and ballistic principles applies to both types. Examples, problems, illustrations, and references are included.

(The) ROYAL SOCIETY EMPIRE SCIENTIFIC CONFERENCE, June–July 1946, Report, 2 volumes. (The) Royal Society, Burlington House, London, W.1, England, 1948. Volume 1, 828 pages; volume 2, 707 pages, diagrams, charts maps, tables, $8^{1}/_{2}$ by $5^{1}/_{2}$ inches, cloth, £2. 2s., two volumes. This 2-volume report covers the following topics in their relation to the British Empire: organization, co-operation, and interchange in scientific research; scientific information services and the collection of scientific records; agricultural science; medical science; nutrition; mapping by air; land utilization and conservation; mineral and other natural resources; postwar needs of fundamental research. The volumes also include a miscellaneous group of papers on a variety of other topics, and some information on the purpose and organization of the Royal Society conference.

SCIENTIFIC FOUNDATIONS OF VACUUM TECHNIQUE. By S. Dushman. John Wiley and Sons, New York, N. Y.; Chapman and Hall, London, England, 1949. 882 pages, illustrations, diagrams, charts, tables, $9^{1}/_{4}$ by $5^{3}/_{4}$ inches, cloth, $15. A comprehensive study of all phases of achieving, maintaining, and measuring very low gas pressures. It presents a survey of fundamental ideas in physics, chemistry, and metallurgy, which will be found useful in dealing with problems in this field. References to the literature appear as footnotes. Both scientific research and practical engineering applications are considered.

STATISTICAL ABSTRACT OF THE UNITED STATES, 69th Edition, 1948, compiled under supervision of M. H. Hansen. United States Department of Commerce, Bureau of the Census, Washington 25, D. C. 1,054 pages, tables, maps, charts, $9^{1}/_{4}$ by $5^{3}/_{4}$ inches, cloth, $2.75. This reference volume incorporates the important summary statistics on population, trade, production, finance, and numerous other subjects. New features of the 69th issue are additional subject material on population forecasts, consumer income, motor fuel consumption, national forests, current industrial production, and size of establishments in the distribution and service industries. A bibliography of sources of statistical data is included.

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THEORY OF DIELECTRICS, DIELECTRIC CONSTANT AND DIELECTRIC LOSS. By H. Fröhlich. Oxford University Press, New York, N. Y.; Clarendon Press, Oxford, England, 1949. 180 pages, diagrams, charts, tables, $8^{3}/_{4}$ by $5^{1}/_{2}$ inches, cloth $4.50. One of a series summarizing recent research results, this book is intended to give a systematic account of the theory of dielectric properties, and thus to provide a background against which applications can be made. In his discussion of the applications of the theory the author covers several important types of materials (nonpolar solids, ionic crystals, dipolar liquids, and so on) as examples.

ELEMENTS OF MECHANICAL VIBRATION. By C. R. Freberg and E. N. Kemler. Second edition. John Wiley and Sons, New York, N. Y.; Chapman and Hall, London, England, 1949. 227 pages, illustrations, diagrams, charts, table, $9^{1}/_{4}$ by 6 inches, cloth, $3.75. Of interest to both students and engineers, this book is a practical, elementary treatment of mechanical vibration, including the mobility method, and the electrical analogue. As in the previous edition, all problems are treated simply from a basic analysis. Two new chapters include material on sound and its engineering applications and on beams.

ENGINEERING OF ORGANIZATION AND MANAGEMENT. By R. T. Livingston. McGraw-Hill Book Company, New York, N. Y.; Toronto, Ontario, Canada; London, England, 1949. 247 pages, diagrams, charts, tables, $9^{1}/_{4}$ by 6 inches, cloth, $3. This fundamental and practical book presents a philosophy of modern management approached as a complete theory, rather than as a specific application. It discusses in detail a function such as decision making, and then presents its point of maximum application. Outstanding chapters consider the necessity for understanding men, the theory of action, and the interlinked cycles of action.

ENGINEERING THE NEW AGE. By J. J. O'Neill. Ives Washburn, Inc., 29 West 57th Street, New York, N. Y., 1949. 320 pages, tables, $8^{1}/_{4}$ by $5^{1}/_{4}$ inches, cloth, $3.50. Presents the story of the individual and the role he will play in the unfolding of the new era in which all our resources are directed toward human welfare. It considers the relationship of man to the cosmos, man to man, and man to his community. It finds an underlying pattern which provides a blueprint for progress in accordance with the methods established by the engineer and scientist.

BERKELEY SYMPOSIUM ON MATHEMATICAL STATISTICS AND PROBABILITY, PROCEEDINGS. Held at the Statistical Laboratory, Department of Mathematics, University of California, August 13–18, 1945, January 27–29, 1946. Edited by J. Neyman. University of California Press, Berkeley and Los Angeles, Calif., 1949. 501 pages, diagrams, charts, tables, $10^{1}/_{2}$ by $6^{1}/_{2}$ inches, cloth, $7.50. Containing 30 papers written by noted scholars and mathematicians, this book covers applications of mathematical statistics and probability to philosophy, astronomy, economics, agriculture biology, forestry, psychology and entomology. Some papers are limited to the presentation of experimental problems requiring statistical treatment. In others statistical theory is important as a tool used to clarify some complex phenomena.

CALCULUS. By L. L. Smail. Appleton-Century-Crofts, Inc., New York, N. Y., 1949. 592 pages, diagrams, charts, tables, $8^{1}/_{4}$ by $5^{1}/_{4}$ inches, cloth, $4.50. Intended for use in a first course in calculus, this book gives due emphasis to the meaning of fundamental concepts, as well as teaching the technique of differentiation and integration and the methods of applying this technique. Integration is introduced early in the course. A list of exercises is placed at the end of nearly every article, and answers to the odd-numbered ones are in the appendix.

CONSTRUCTIVE USES OF ATOMIC ENERGY. By S. K. Allison and others, edited by S. C. Rothmann. Harper and Brothers, New York, N. Y., 1949. 258 pages, illustrations, diagrams, charts, tables, $8^{1}/_{4}$ by $5^{1}/_{2}$ inches, cloth, $3. This volume brings together 14 articles by specialists describing the current uses of atomic energy in the fields of industrial power, chemistry, metallurgy, aviation, ceramics, soil-fertilizer research, biology, and medicine, and pointing out the possibilities of future development. An appendix contains a glossary, a classified bibliography, and a chronological list of significant dates.

DIFFERENTIAL EQUATIONS. By H. W. Reddick. Second edition. John Wiley and Sons, New York, N. Y.; Chapman & Hall, Limited, London, England, 1949. 288 pages, diagrams, tables, $8^{1}/_{2}$ by $5^{1}/_{2}$ inches, cloth, $3. Deals with methods of solving ordinary differential equations and with related problems in applied mathematics, stressing the importance of the physical units involved. Changes in this second edition include a new chapter on the linear equation of the second order and additional material on hyperbolic functions, systems of curves, and vibratory motion.

DIRECT-CURRENT ARMATURE WINDINGS, THEORY AND PRACTICE. By C. S. Siskind. McGraw-Hill Book Company, New York, N. Y., Toronto, Ontario, Canada; London, England, 1949. 149 pages, illustrations, diagrams, charts, tables, 10 by 7 inches, cloth, $3. Fundamental principles are treated in a simple understandable form for the use of the student and the shop worker. Simplified formulas are given for the calculation of construction details, testing procedures are described for trouble location, and problems are worked out to demonstrate desirable winding modifications. A special attempt has been made to provide effective diagrams and illustrations.

ELECTRONICS IN THE FACTORY. Edited by H. F. Trewman. Sir Isaac Pitman and Sons, London, England, 1949. 187 pages, illustrations, diagrams, charts, $8^{1}/_{2}$ by $5^{1}/_{2}$ inches, fabrikoid, 20s. This small book provides a description of the latest applications of electronics to industrial production. The various chapters deal with electronic heating, welding control, electronics in chemistry, electronics in medicine, and with electronic devices for timing, counting, motor and generator control, and voltage and current regulation.

ELECTRONICS MANUAL FOR RADIO ENGINEERS. By V. Zeluff and J. Markus. McGraw-Hill Book Company, New York, N. Y.; Toronto, Ontario, Canada; London, England, 1949. 879 pages, illustrations, diagrams, charts, tables, 11 by $8^{1}/_{2}$ inches, cloth, $9.50. Logically arranged according to the major interests of the radio field, this compilation includes 289 articles published in the magazine *Electronics* during the period 1940–48. It provides the practical circuit information needed by practicing engineers, the mathematical foundations needed by radio design engineers and researchers, the measuring and operating techniques needed by radio operators and maintenance men, and miscellaneous items useful to radio production men.

ELEMENTS OF SOUND RECORDING. By J. G. Frayne and H. Wolfe. John Wiley and Sons, New York, N. Y.; Chapman & Hall, Ltd., London, England, 1949. 686 pages, illustrations, diagrams, charts, tables $9^{1}/_{4}$ by 6 inches, cloth, $8.50. Providing useful information on basic sound problems, this book is of interest to the practical designer, operating engineer, and technician. It covers topics from the nature of sound to stereophonic recording. Subjects which belong exclusively to the restricted field of sound recording and reproducing are treated in detail. Closely related subjects are discussed briefly. For added clarity, numerical examples are used in a number of instances to illustrate the use of design formulas, and there is a limited use of complex mathematics.

ENGINEERING ECONOMICS AND PRACTICE INCLUDING SOLUTIONS TO PROBLEMS IN PROFESSIONAL ENGINEER EXAMINATIONS, NEW YORK STATE. By M. J. Steinberg and W. Glendinning. Apply W. Glendinning, 5123 Bell Boulevard, Bayside, N. Y., 1949. 101 pages, diagrams, charts, tables, $11^{1}/_{2}$ by $8^{1}/_{2}$ inches, paper, $3. Covers the basic principles of engineering economics and practice. The principles have been reduced to a formula basis with each of the terms clearly defined. Each chapter includes problems of a practical nature that illustrate the principles involved. Questions and solutions to the problems in engineering economics and practice from the

New York State professional engineering examinations are an important supplement to the text material.

HYDRO-ELECTRIC ENGINEERING. By G. Gerard. Sir Isaac Pitman and Sons, Ltd., London, England, 1949. 181 pages, illustrations, diagrams, charts, maps, tables, 8³/₄ by 5¹/₂ inches, cloth, 20s. Written from the practical angle, this book outlines the civil, mechanical, and electrical aspects of hydroelectric engineering. To illustrate certain of the principles touched on, an appreciable space is devoted to descriptions of typical hydroelectric plant and schemes in operation in various parts of the world.

INDUCTION HEATING. By N. R. Stansel. McGraw-Hill Book Company, New York, N. Y.; Toronto, Ontario, Canada; London, England, 1949. 212 pages, illustrations, diagrams, charts, tables, 9¹/₄ by 6 inches, cloth, $3.50. Supported by measurements to provide a factual basis, this book presents the electrical and thermal principles of the use of eddy currents for industrial heating service. It shows how these principles are applied in practice and indicates the procedures for the development of new uses of this method of heating. The examples cover the entire range of practice in the heating of metals and metal parts.

INTRODUCTION TO RADIOCHEMISTRY. By G. Friedlander and J. W. Kennedy. John Wiley and Sons, New York, N. Y.; Chapman and Hall, Limited, London, England, 1949. 412 pages, illustrations, diagrams, charts, tables, 8¹/₂ by 5¹/₂ inches, cloth, $5. Presupposing no previous knowledge of nuclear physics, this volume is prepared as a textbook for an introductory course in the broad field of radiochemistry at the graduate or senior undergraduate level. The first five chapters provide historical and basic background material. The remaining chapters consider a quantitative treatment of radioactive decay processes, the various types of radioactive disintegration, a statistical treatment of radioactivity, data and the applications of radioactivity to chemistry.

MAGNETIC RECORDING. By S. J. Begun. Murray Hill Books, New York, N. Y., and Toronto, Ontario, Canada, 1949. 242 pages, illustrations, diagrams, charts, tables, 9¹/₂ by 6¹/₄ inches, cloth, $5. A detailed discussion of the fundamentals and components of efficient magnetic recording devices. The theory, various types and makes of recorders, their applications, and performance measurements are all treated. Starting with the history and theory of the art, it concludes with a brief consideration of the important research problems facing the industry.

MAINTENANCE MANUAL OF ELECTRONIC CONTROL. Edited by R. E. Miller. McGraw-Hill Book Company, New York, N. Y.; Toronto, Ontario, Canada; London, England, 1949. 304 pages, illustrations, diagrams, charts, tables, 9¹/₄ by 6 inches, cloth, $4.50. Based on a series of articles published in *Electrical Construction and Maintenance*, this book is a practical installation, maintenance, and service manual for the electrical and electronic technician. Involving no mathematics and requiring only a fundamental knowledge of electricity, it takes the reader from simple electric circuits through the more complicated circuits for electronic control devices. The remaining chapters consider the use and adaptation of tools and instruments for servicing pecific types of equipment.

PULSES AND TRANSIENTS IN COMMUNICATION CIRCUITS. By C. Cherry. Chapman and Hall, Ltd., London, England, 1949. 317 pages, illustrations, diagrams, charts, tables, 8³/₄ by 5¹/₂ inches, cloth, 32s. Bridging the gap between simple conventional alternating current theory and operational methods of analysis, this book serves as an introduction to circuit transient analysis. It provides essential groundwork, using rigorous physical arguments and only elementary mathematics. References to the literature are given.

SYMPOSIUM ON MAGNETIC TESTING (1948). (Special Technical Publication Number 85). American Society for Testing Materials, 1916 Race Street, Philadelphia 3, Pa., 1949. 198 pages, illustrations, diagrams, charts, tables, 9 by 6 inches, paper, $2.50; cloth, $3.15. This publication, with ten technical papers by leading experts in their fields, covers some of the new advances in magnetic testing and analysis. This symposium discusses the extent of present knowledge and indicates the progress which has been made.

TERRESTRIAL MAGNETISM AND ELECTRICITY. (Physics of the Earth—VIII). Edited by J. A. Fleming and others. Dover Publications, New York, N. Y., 1939 edition reprinted with corrections in 1949. 794 pages, illustrations, diagrams, charts, maps tables, 9¹/₂ by 6 inches, cloth, $4.95. Written by outstanding scientists in the field, this reprint of volume VIII of the "Physics of the Earth" series surveys the findings of modern geophysicists in the field of terrestrial magnetism.

(A) TEXT-BOOK OF PHYSICS FOR STUDENTS OF SCIENCE AND ENGINEERING. By J. Duncan and S. G. Starling. Macmillan Company, Ltd., London, England, Second edition revised, 1948. 1,063 pages, illustrations, diagrams, charts, tables, maps, 8³/₄ by 5¹/₂ inches, cloth, $5.50. Connecting the scientific aspects of physics with modern practical applications this British text is meant for those preparing for examinations given by universities, armed services, and guilds. It deals with the principles and applications of the topics usually dealt with in physics texts. A large number of worked-out examples are included and there are unsolved problems at the end of each chapter.

MICRO-WAVES AND WAVE GUIDES. By H. M. Barlow. Dover Publications, New York, N. Y., 1949. 122 pages, diagrams, charts, tables, 8³/₄ by 5¹/₂ inches, cloth, $1.95. Written for the engineer and physicist, this small book includes all the essentials needed for an advanced understanding of the subject. It opens with a physical picture of wave-guide modes, synthesized from constituent plane waves in association with ordinary transmission line elements. Characteristic features of wave-guide propagation are discussed as well as the coaxial cable. The final section deals briefly with the measurements and applications of microwaves. The MKS system of units (not rationalized) is used.

TECHNICAL LITERATURE. By G. E. Williams. George Allen and Unwin, Ltd., London, England, 1948. 117 pages, diagrams, tables, 7¹/₂ by 5 inches, cloth, 7s.6d. Following a brief introductory chapter the author considers three main aspects of presentation: ideas and their logical arrangement; the language in which the ideas are expressed; and their organization in paragraphs and sections. The preparation of manuscripts and illustrations in a form acceptable to societies and professional institutions is discussed in detail.

TWO LECTURES: 1. Present Situation in the Theory of Elementary Particles. 2. Electron Theory of Superconductivity. By W. Heisenberg. University Press, Cambridge, England; American Branch, 51 Madison Avenue, New York, N. Y., 1949. 52 pages, diagrams, 7¹/₂ by 4³/₄ inches, cloth, $1. The two lectures presented in this volume were delivered at the Cavendish Laboratory. In the first lecture the author tries to explain why the well-known divergencies in meson theory and nuclear physics may be considered as a natural feature of the present 'correspondence' theory. The second lecture deals with an application of quantum mechanics, the theory of superconductivity.

ADVANCED CALCULUS FOR ENGINEERS. By F. B. Hildebrand. Prentice-Hall, New York, N. Y., 1949. 594 pages, diagrams, tables, 8¹/₂ by 5¹/₂ inches, cloth, $8. An integrated presentation of special topics and useful methods of calculus found to be essential to engineers and physicists. The first five chapters are concerned with ordinary differential equations; succeeding chapters deal with ideas and tools of vector analysis, introduce and apply the basic concepts of partial differential equations, and discuss the theory of a complex variable. Problems with answers are included.

BASIC ELECTRONICS. By R. G. Kloeffler with the assistance of M. W. Horrell. John Wiley and Sons, New York, N. Y.; Chapman and Hall, Ltd., London, England, 1949. 435 pages, illustrations, diagrams, charts, tables, 9¹/₁ by 6 inches, cloth, $5. Intended as a text for electrical engineering students specializing in power work, this book serves as an introduction to the physics and basic theory of electronic tubes and associated components. The essentials of rectification, amplification, oscillation, modulation, and detection are concisely covered. Curves and data of the basic tubes are included. Nine of the 17 chapters are taken from Professor Kloeffler's "Industrial Electronics and Control."

DESCRIPTION OF A RELAY CALCULATOR. By the Staff of the Computation Laboratory, Harvard University Press, Cambridge, Mass., 1949. 366 pages, illustrations, diagrams, charts, tables, 10³/₄ by 8 inches, cloth, $8. This volume is a description of the relay calculator formerly known as Mark II, that was built by the Computation Laboratory of the Bureau of Ordnance of the United States Navy. The design and construction are described in detail, as well as problem preparation and solutions of typical examples. A manual of operation is included.

PAMPHLETS • • • • •

The following recently issued pamphlets may be of interest to readers of "Electrical Engineering." All inquiries should be addressed to the issuers.

Offshore Petroleum Bibliography. The Division of Oceanography and Meteorology of the Southwest Research Institute, as one of its first contributions in the oceanographic field, has published a bibliography, "Offshore Petroleum Developments," by Emory N. Kemler, which summarizes the literature available on deep water operations in connection with petroleum production. Requests for copies should be sent to the Division at 312 Oil and Gas Building, Houston, Tex.

X-Ray Diffraction Studies on the Progress of Gelatinization in Drying Oil . This 4-page folder explains how the Geiger counter X-ray spectrometer is employed in making studies of: films produced from oils or alkyds; gelatinized oils; and insoluble portion of oils. Available at ten cents per copy from V. W. Palen, Bureau of Public Information, New York University College of Engineering, New York 53, N. Y.

High-frequency Voltage Measurements, by Myron C. Selby. National Bureau of Standards Circular 481. Dealing with measurements in the upper audio- and radio-frequency ranges, including part of the ultra-high-frequency range, this 14-page leaflet discusses high-precision methods based on d-c measurements, moderate precision measurements, and pulse-peak voltage measurements. Available at 20 cents per copy from the Superintendent of Documents, United States Government Printing Office, Washington 25, D. C.

Medical X-Ray Protection Up to 2,000,000 Volts. National Bureau of Standards Handbook 41. Gives comprehensive and practical recommendations for the protection of the radiation worker. This 43-page booklet was prepared by the NBS-sponsored National Committee on Radiation Protection. Priced at 15 cents a copy, the pamphlet is available from the Superintendent of Documents, Government Printing Office, Washington 25, D. C.

Tables of the Confluent Hypergeometric Function $F\left(\frac{n}{2}, \frac{1}{2}; x\right)$ and Related Functions. National Bureau of Standards Applied Mathematics Series 3. 73 pages of tables, designed to be of value to the statistician, especially in computing the power of analysis-of-variance tests. Available at 35 cents from the Superintendent of Documents, Government Printing Office, Washington 25, D. C.

United States Government Films for School and Industry. Lists, describes, and gives purchase price of 1,964 motion pictures and film strips, prepared for educational purposes by 13 Government agencies. Catalogue is available upon request from Castle Films, Division of United World Films, Inc., 1445 Park Avenue, New York 29, N. Y.

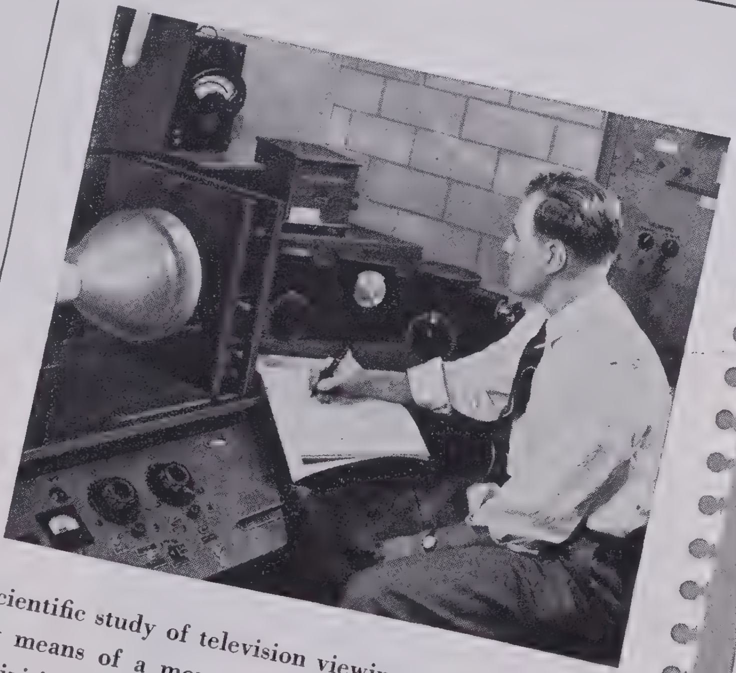
A page from the note-book of Sylvania Research

Monochrometer studies help reduce contrast degradation in television images

During recent studies made by Sylvania Electric to reduce contrast degradation in video images, a basic optical instrument, the monochrometer was used to determine the actual shape of light transmission curves. These studies have led the way towards the creation of "dark-faced" viewing tubes . . . which give better contrast in television images than was previously possible with the use of external viewing filters alone.

The new gray face plate holds light transmission to about 66 per cent. It reduces the amount of light spreading to dark areas of the television picture as a result of reflection within the face plate. It also reduces the amount of light reflected from other light sources in the room.

Sylvania continually finds new uses for known tools . . . employing them—in addition to new devices—to bring you the best products of scientific research.



Scientific study of television viewing tube light output by means of a monochrometer is one of the regular activities at the Physics Laboratory in Bayside, N. Y. Here an engineer is carefully comparing the light output from a television viewing tube with a known light source in the instrument.

SYLVANIA ELECTRIC

ELECTRONIC DEVICES; RADIO TUBES; CATHODE RAY TUBES; FLUORESCENT LAMPS, FIXTURES, WIRING DEVICES, SIGN TUBING; LIGHT BULBS; PHOTOLAMPS

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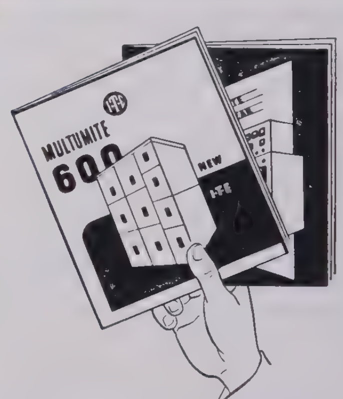
I-T-E MULTUMITE SWITCHGEAR FEATURES EASIER ACCESS TO BREAKERS!

On both high- and low-voltage Multumite Switchboards, the easy-to-remove breakers are praised by maintenance men. I-T-E 5KV Breakers are truck-mounted for quick, easy withdrawal from compartments. Low-voltage I-T-E Breakers are pantograph-mounted, and all components are accessible when breaker is withdrawn. In the fully withdrawn position, breaker can easily be removed; the metal feet on its base make it a self-standing unit. Both HV and LV breakers may be tested while still in their compartments.



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to I-T-E 600V Switchgear assemblies. C
tains detailed information on I-T-E Mu
mite and helpful facts for specifying a
ordering complete switchgear installatio

BULLETIN 7000-A: Describes I-T-E's new
5KV Switchgear — illustrated and supp
mented with practical, easy-to-read dra
ings and diagrams. If you have any questio
on modern HV switchgear construction
will pay you to have this bulletin.

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your local I-T-E Representative or write I-T
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You'll discover how easy—and economical—solving electrical distribution problems actually is when you put the I-T-E organization to work for you. I-T-E furnishes everything you need in engineering and equipment. For instance, here's what you get when I-T-E supplies your switchgear:

- PROPER APPLICATION FOR YOUR SPECIFIC NEEDS: Every I-T-E Sales Engineer is a *switchgear specialist*—fully qualified to assist you in planning all parts of your distribution system. Thus, your I-T-E Switchgear is designed for your specific problems—built to meet your needs!

- EFFECTIVE, PROPERLY COORDINATED UNITS: I-T-E supplies the finest components for every part of your distribution system. I-T-E's own equipment is designed better to last longer. Purchased auxiliaries must meet highest standards of excellence. And all components are coordinated by I-T-E's engineers into efficient, functional units of maximum dependability.

- QUICK, EASY INSTALLATION: Your I-T-E equipment is completely assembled and tested by I-T-E *before* shipment. It is delivered to you, ready for connections. Installation is simplified; chances of failure because of improper assembly are minimized.

- A SYSTEM THAT'S EASY TO OPERATE, EASY TO MAINTAIN: All components of I-T-E units are functionally arranged for easy, simple operation. And your maintenance men will be enthusiastic when they see how much more *accessible* I-T-E units are. Inspections and maintenance are easier, take less time!

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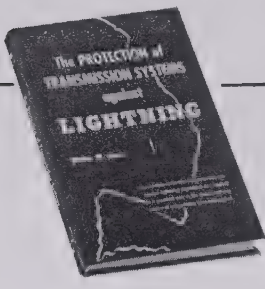
SPECIAL PRODUCTS

JUST PUBLISHED!

THE PROTECTION OF TRANSMISSION SYSTEMS AGAINST LIGHTNING

By WALTER W. LEWIS



This is the first time all the important information on lightning has been compressed into a single book for the engineer in the power field. The author has applied this information in a practical way to the design and protection of transmission lines. He discusses all significant tests and experiments which have been made since 1924, and describes the instruments which were used in them.

BASIC INFORMATION PLUS PRACTICAL METHODS

The first five chapters give basic information on lightning waves. The rest of the book contains practical rules to guide plant owners, designers, constructors, and operators. Rules are given for the proper coordination of line insulation and spacing of conduits for the most effective arrangement of overhead ground wires, and for grounding lines and stations. Thorough coverage is given to alternative methods of protecting transmission lines (both low voltage and high voltage, stations and rotating machines).

January 1950 418 pages $8.00

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INDUSTRIAL NOTES ....

W. H. Sharpe, Rome Cable Sales Service Manager, Dies. William H. Sharpe, 50, Sales Service Manager of the Rome Cable Corporation, Rome, N. Y., died recently. Mr. Sharpe joined the company in 1936, during the first year of its operation.

G-E News. Planned expansion of the General Electric Company's transformer manufacturing and testing facilities at Pittsfield, Mass., will more than double the company's power transformer production capacity. The new facilities, costing "several million dollars," are expected to be placed in operation about the middle of 1950, and will permit the testing, assembling, and shipping of three-phase power transformers with more than twice the capacity of any transformers yet built, and will make it possible to test transformers as large as any that may be built in the foreseeable future. Tests to be conducted at the new facilities are based on research at the company's new High Voltage Engineering Laboratory.

General Electric has also announced the election of Fred F. Harroff, General Manager of the company's Lamp Department, as a Vice-President of the company. Mr. Harroff, who will retain his position with the Lamp Department at Nela Park, Cleveland, Ohio, succeeds Martin L. Sloan, who has retired. Other appointments at General Electric include: G. K. Iwashita, named Manager of Product Planning of the company's Air Conditioning Department; Leo F. Brown, appointed Plant Manager of the air conditioning equipment plant, Air Conditioning Department; Edward D. Kemble, Plant Manager of the Automatic Heating Division; Edward T. Carvill, appointed Assistant Manager of appliance sales in the southeastern district; and Monte M. Wheeler, named Sales Manager of the company's Automatic Blanket and Sunlamp Division at Bridgeport, Conn.

President of Ohio Brass Elected to NAM Board of Directors. George L. Draffan, President of the Ohio Brass Company, has been elected to the Board of Directors of the National Association of Manufacturers. He will serve for the year 1950, and will represent the Central Ohio District. Mr. Draffan is also an active member of the organization's Community Leaders Committee.

Westinghouse Appointments. J. L. Cross has been made Manager of Power Transformer sales for the Westinghouse Transformer Division at Sharon, Pa. Mr. Cross succeeds C. H. Bartlett, who has recently been appointed Sales Manager for the entire Transformer Division. Other appointments at the Westinghouse Electric Company are those of: J. O. Clevenger as Manager of the company's Welding Department; J. P. Coughlin, Manager of Field Sales, same department, at Buffalo, N. Y.; and John E. Payne as Manager of the Westinghouse central district, with headquarters in Pittsburgh, Pa.

Allis-Chalmers Announces Retirement Plan. The Allis-Chalmers Manufacturing Company is preparing a proposed retirement plan for all of its 30,000 employees, and in addition, is studying improvements in its health and accident plan recently suggested by the West Allis works Mutual Aid Society. The mutual aid societies are operated locally at each plant, with the company matching employee's contributions. The combined initial annual cost of the two programs, with other insurance benefits now in effect, was estimated to be approximately 11 cents per pay roll hour or between $6,000,000 and $7,000,000.

Padmore Retires From Bell. Edward J. Padmore has retired from his post as Traffic Supervisor of Overseas Services, after 48 years of service with the Bell System. Mr. Padmore is credited with developing new operating methods which contributed greatly to increased speed of overseas telephone traffic and which, since their inception, have been adopted by other telephone companies around the world. In 1930, when Mr. Padmore took over overseas traffic supervision, about 16,000 calls were made from this country to overseas points. Last year, nearly 600,000 messages were recorded, indicating the progress made during Mr. Padmore's service.

Coffin Named RCA Victor Advertising Director. Ralston H. Coffin has been appointed Director of Advertising for the RCA Victor Division, Radio Corporation of America.

Aerovox Acquires Electrical Reactance Company. The Aerovox Corporation of New Bedford, Mass., has purchased the entire outstanding stock of the Electrical Reactance Company. The latter, with plants at Franklinville, N. Y., Jessup, Pa., and Myrtle Beach, S. C., manufactures ceramic capacitors for the radio and television fields, while Aerovox manufactures capacitors for the automotive, electrical appliance and fluorescent lighting industries. Electrical Reactance will be operated as a wholly-owned subsidiary under the continuing management of Charles E. Kramph, President, who also becomes a Director of Aerovox.

Dugall Plant Manager of Kaiser Aluminum Cable. J. T. Dugall, formerly Plant Manager of the General Cable Corporation's Rome, N. Y. facilities, has been appointed Plant Manager of the Kaiser Aluminum Cable plant at Newark, Ohio. Kaiser Aluminum and Chemical Corporation also announced that November shipments of aluminum was the greatest for any one month in the company's history.

Insulation Manufacturers Expands Sales Services. Insulation Manufacturers Corporation has opened a new sales office in

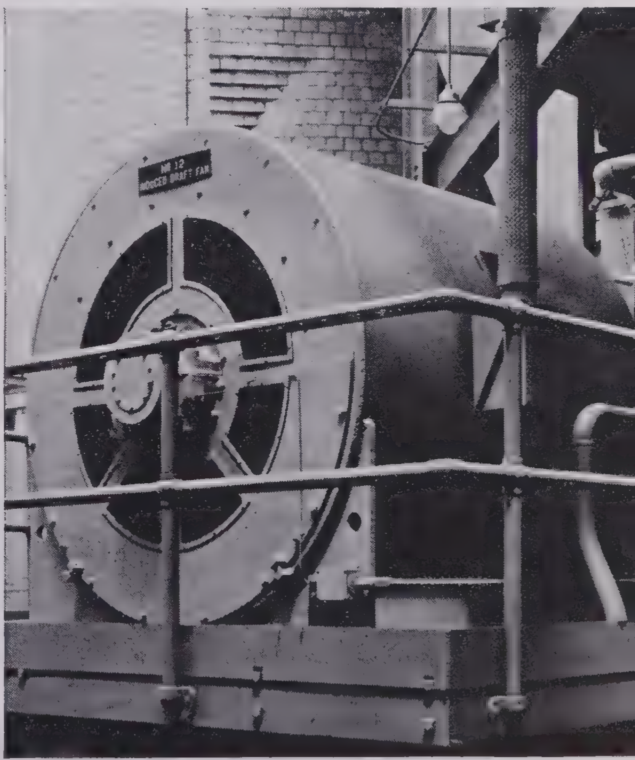
(*Continued on page 26A*)

Unusual 220 kv Units Used in West Coast Utility

In line with the increased usage of high voltage transmission is the installation of these three 220,000 volt transformers. Their corona-free insulation is especially important in making these transformers long lived and strong without deterioration under severest impulse voltages . . . even when repeated time after time. A feature of these units is the load ratio control on the low voltage (72,000 volt) winding, which is unusual for a transformer of this size. Each unit is single phase and rated 25,000 kva.

Public Service Electric & Gas Co., N.J. ...46 Motors

Tube type totally enclosed, fan-cooled motor shown is one of 46 large Allis-Chalmers motors at Sewaren. Tube type, fan cooled design is well suited to this type of outdoor draft fan operation. The motor rarely, if ever, needs cleaning because tubes are straight, air passages are unrestricted, and the cooling air flows at sufficient speed to carry foreign matter out with it. This motor is ideal for hazardous or dirty locations indoors or outdoors.



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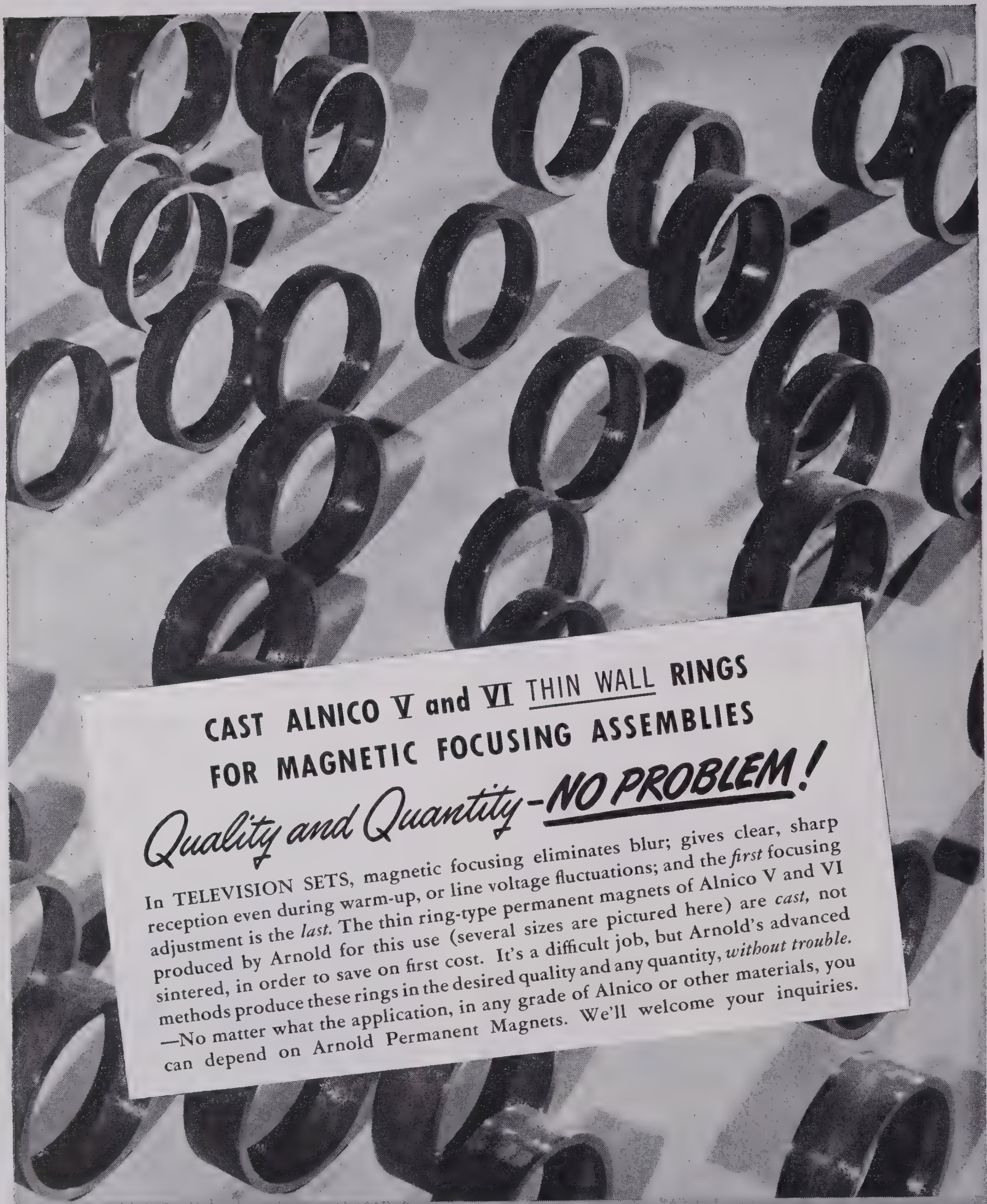

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In TELEVISION SETS, magnetic focusing eliminates blur; gives clear, sharp reception even during warm-up, or line voltage fluctuations; and the *first* focusing adjustment is the *last*. The thin ring-type permanent magnets of Alnico V and VI produced by Arnold for this use (several sizes are pictured here) are *cast*, not sintered, in order to save on first cost. It's a difficult job, but Arnold's advanced methods produce these rings in the desired quality and any quantity, *without trouble.* —No matter what the application, in any grade of Alnico or other materials, you can depend on Arnold Permanent Magnets. We'll welcome your inquiries.

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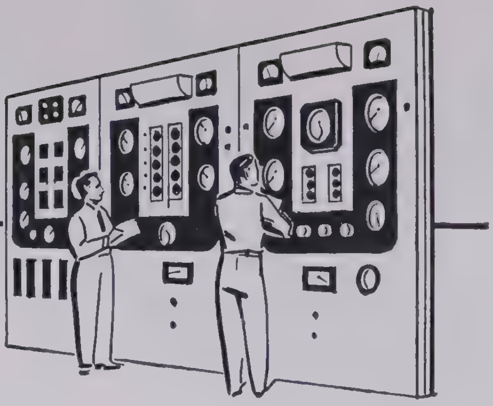
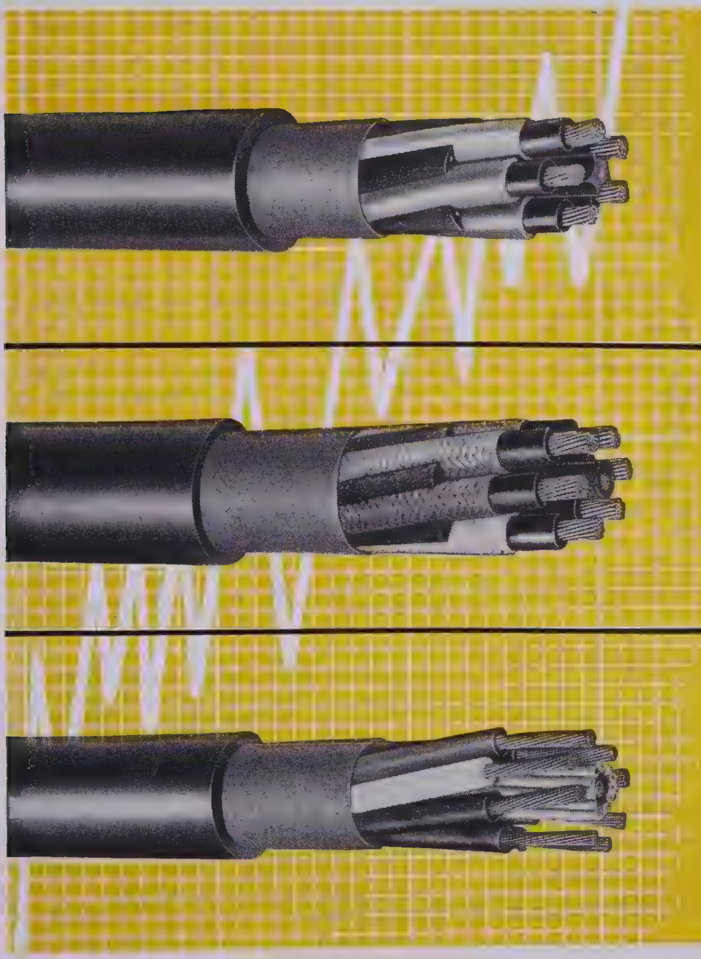
CONTROL CIRCUIT FAILURES



Rome Control Cables pay off by preventing failure where it hurts the most . . . in control circuits . . . the nerve center of your power distribution system. They are permanently dependable under extreme service conditions. Rome Control Cables are designed for versatility of application, with outer sheath protection against moisture, sunlight, oil, alkalies, acids, and flame. Installation may be by direct burial, in conduit or duct, in open air, or runs combining all three. Typical control cable constructions embody rubber, Neoprene and thermoplastic compounds. Sign and return coupon below for available size and conductor combinations, and test data.



ROZONE-ROPRENE CONTROL CABLES

A superior quality construction possessing the highest degree of resistance to heat, moisture, corona and ozone cutting. Individual conductors are insulated with RoZone, a high quality oil base compound and are sheathed with Neoprene for complete protection where fanned out at terminals. Assembled with rubber-like fillers and protected over all with a RoPrene (Neoprene) sheath. Recommended for operating temperatures up to 75° C. Rated at 600 V. Ask for Specification CRO-1.

ROMARINE-ROPRENE CONTROL CABLES

Here is the popular combination of RoMarine, a superaging and moisture resistant insulating compound and a RoPrene (Neoprene) sheath. Individual conductors are protected with color coded fibrous braids (or Neoprene when specified) and assembled with jute fillers. Recommended for general purpose control and signal installations for operating temperatures up to 75° C. Rated for 600 V. Ask for specification CRM-1.

ROME SYNTHINOL* CONTROL CABLES

Rome Synthinol Control Cables are the practical answer where thermoplastic insulation and sheath are desired. Rome Synthinol (polyvinyl chloride) is highly resistant to flame, moisture, oils, chemicals, and corrosive fumes. Fanned out conductors are individually protected with Rome Synthinol thermoplastic compound and are permanently coded in clear colors for easy circuit identification. Recommended for operating temperture up to 60° C. Rated for 600 V. Ask for Specification CT-1.

*TRADEMARK REGISTERED

It Costs Less to Buy the Best . . . Buy Rome Control Cables

ROME CABLE CORP., Dept. EE-2, Rome, N. Y.
Please forward Control Cable Specifications as follows:

....
Name ....
Company ....
Address ....
City .... *State* ....

ROME CABLE
Corporation
ROME · NEW YORK
From Bar to Finished Wire

ROME CABLE
ROME, N.Y.

STRUTHERS DUNN

Military Type MINIATURE MULTI-POLE D-C RELAY

Here are miniature, low wattage d-c relays that really stand up under extreme conditions of shock and vibration. False contact operation is avoided without sacrificing desirable electrical characteristics—and at no extra relay cost. Available in any contact arrangement up to 4-pole double-throw. Open, plug-in base, metal encased or hermetically-sealed types. Write for Bulletin L2610.

STRUTHERS-DUNN, INC.
150 N. 13th St., Philadelphia 7, Pa.

BALTIMORE • BOSTON • BUFFALO • CHARLOTTE • CHICAGO • CINCINNATI CLEVELAND • DALLAS • DETROIT • KANSAS CITY • LOS ANGELES • MINNEAPOLIS • MONTREAL • NEW ORLEANS • NEW YORK • PHILADELPHIA • PITTSBURGH • ST. LOUIS • SAN FRANCISCO • SEATTLE • SYRACUSE • TORONTO

(Continued from page 16A)

Pittsburgh, Pa., as a result of the increasing demand in that area for electrical insulation products. William A. Carlstrom will act as Manager of the new office, and Miss Katherine Husted will be associated with him.

Holyoke Machine Company Appointment. L. H. Perry has been named to head the Hydraulic Department of the Holyoke Machine Company, Holyoke, Mass., builders of hydraulic turbines and water wheels.

United States Testing and Esselen Research Merge. Two scientific laboratories, the United States Testing Company, Inc., Hoboken, N. J., and the Esselen Research Corporation, Boston, Mass., have announced their integration. The Esselen Research Corporation will now be known as the Esselen Research Division of the United States Testing Company, Inc., and will continue its operations in Boston under the direction of Dr. Gustavus J. Esselen, its founder.

Gates Opens New Southwestern Factory Branch. The Gates Radio Company, of Quincy, Ill., has opened a southwestern factory branch in Houston, Tex., at 2700 Polk Avenue. Wayne E. Marcy has been appointed the southwestern Branch Manager, and Joseph Woods, Store Manager.

Electric Industrial Truck Elects Officers. New officers of The Electric Industrial Truck Association, elected at the annual meeting, are as follows: M. W. Heinritz, of Trenton, N. J., President; W. A. Meddick, of Cleveland, Ohio, Vice-President; and W. Van C. Brandt, of Philadelphia, Pa., re-elected Secretary-Treasurer.

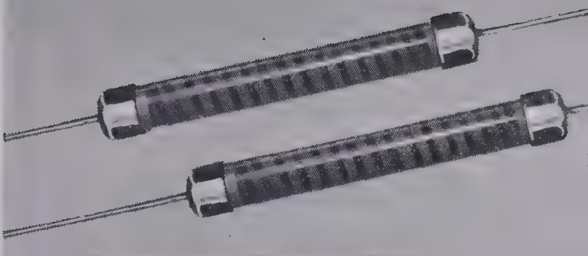
NEW PRODUCTS • •

Westinghouse Developments. The Westinghouse Electric Corporation, P.O. Box 868, Pittsburgh, Pa., has announced the following recent developments:

1. A new line of squirrel cage, totally enclosed, type CSP explosion-proof Life-Line motors. Designed for constant speed drive applications, the motors may be safely used in any location where Class I Group D explosive materials or atmospheres are encountered. Available in frames 224 to 326, in 1- to 20-horsepower ratings, for 2- and 3-phase, 25-, 50-, 60-cycle, 208-, 220-, 440-, and 550-volt service.
2. Standardized control centers containing motor starter units for the centralized control of groups of machines. Safety features of the unit are that the plug-in type disconnects on the line side, and individual starter units are baffled from each other to keep short circuits localized.
3. Machine-tool control transformers which are particularly adapted to the induc-

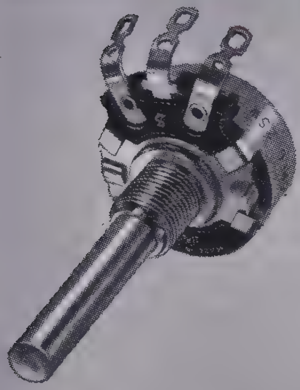
(Continued on page 30A)

important



IN HIGH VOLTAGE APPLICATIONS, where high resistance and power are required, Type MVX high ohmic, high voltage resistors afford exceptional stability. Construction is similar to that of Type MV, but distinctive terminal permits mounting through a hole in mounting block of insulating material without terminal interference. Long resistance path permits use of high voltage on resistor while keeping voltage per unit length of path comparatively low. Check coupon for Catalog G-2.

IN CRITICAL HIGH-FREQUENCY CIRCUITS, Type MP High Frequency Resistors offer dependable performance and unusual stability. Special resistance film on a steatite ceramic form provides a stable resistor with low inherent inductance and capacity—entirely suitable for broad band RF amplifiers, RF probes, dummy loads for transmitters, television sideband filters, radar pulse equipment, and other circuits involving steep wave fronts. Send coupon for Bulletin F-1.



NEW TYPE Q CONTROL offers many advantages to engineers and purchasing agents. Its modern 15/16'' diameter size features a one-piece dual contactor of thin, high-stress alloy; simplified single-unit collector ring; molded voltage baffles; and special brass element terminals that will not loosen or become noisy when bent or soldered. Increased arc of rotation provides same resistance ratio as larger IRC controls. Salt-spray materials are employed. Complete mechanization in manufacture assures absolute uniformity and provides a dependable source of supply for small control requirements. Coupon brings you full details in Catalog A-4.

When you have special need of maintenance or experimental quantities of standard resistors in a hurry, simply phone your local IRC Distributor. IRC's Industrial Service Plan keeps him fully stocked with the most popular types and ranges—enables him to give you 'round-the-corner delivery of small order requirements. We'll gladly send you his name and address.

IRC

Wherever the Circuit Says -ᴧᴧᴧ-

Power Resistors • Voltmeter Multipliers • Insulated Composition Resistors • Low Wattage Wire Wounds • Controls • Rheostats • Voltage Dividers • Precisions • Deposited Carbon Precistors • HF and High Voltage Resistors • Insulated Chokes.

INTERNATIONAL
RESISTANCE COMPANY

401 N. Broad Street, Philadelphia 8, Pa.
In Canada: International Resistance Co., Ltd., Toronto, Licensee

INTERNATIONAL RESISTANCE CO.
411 N. BROAD ST., PHILADELPHIA 8, PA.

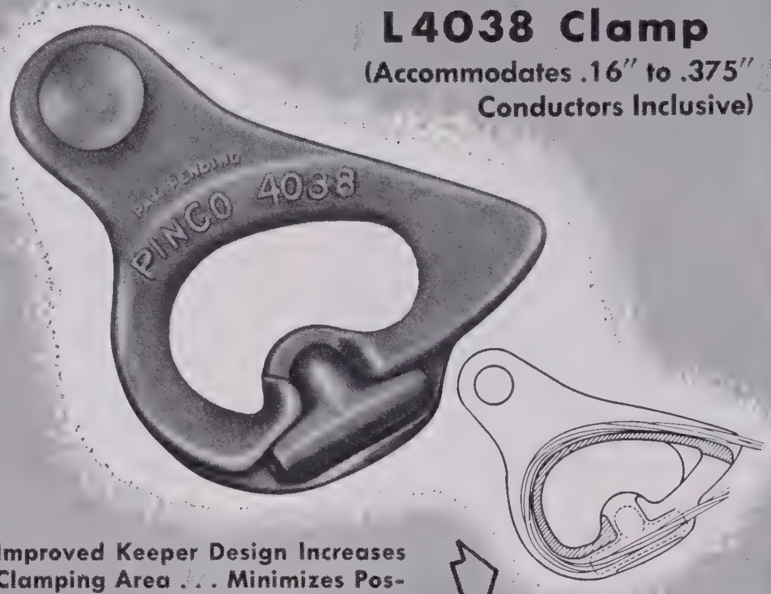
Please send me complete information on the items checked below:

☐ New "Q" Controls ☐ MP High Frequency Resistors
☐ BW Insulated Wire Wounds ☐ MVX High Voltage Resistors
☐ Name of Local IRC Distributor

NAME..
TITLE..
COMPANY...
ADDRESS...
....

RIGHT *for the* JOB . . . RIGHT ON THE JOB!

PINCO'S NEW
L4038 Clamp
(Accommodates .16″ to .375″ Conductors Inclusive)



Improved Keeper Design Increases Clamping Area . . . Minimizes Possibility of Damage to Conductor.

For the past ten years, men who "know" clamps have maintained that the PINCO L 4038 was "tops" in its class. And they were right, because here was the *first* dead-end clamp that had no loose parts in conductor assembly . . . replacing a design that had eight! It also showed improved vibration characteristics with small copperweld or stranded copper conductors. Now this clamp has been made even more efficient because an *extra long* J-Bolt Keeper *doubles* the gripping area on the conductor (contacts *all* wires in the long-lay conductors) . . . holds them securely yet without damage to conductor wires.

So here again is another typical example of Pinco planning which pays off in improved product performance . . . making the Pinco phrase—"RIGHT *for* the Job—RIGHT *on* the Job" one to remember whenever you specify and buy insulators and line hardware.

The Porcelain Insulator Corporation
763 Main Street, Lima, N. Y.

Sales Agents: JOSLYN MFG. & SUPPLY CO.
Offices in Principal Cities

PINCO INSULATORS

Suspension Insulators . . . Switch and Bus Insulators . . . Distribution Clamps . . . Distribution Pin Types and Guy Strains . . . Transmission Line Fittings . . . Tree Insulators . . . Transformer and Circuit Breaker Bushings . . . One Piece and Multi-part High Voltage Pin Types . . . Suspension and Strain Clamps . . . Indoor Bus Support Porcelain . . . Lightning Arrester Porcelain.

• 1920 Thirty Years Service to the Electrical Industry 1950 •

(Continued from page 26A)

tive, low-power factor loads of solenoids, relays, and contactors making up machine tool control equipment. Secondary voltage of these 60-cycle transformers remains above 90 per cent of rated voltage up to a load current of seven times normal at 20 per cent load power factor. Seven sizes from 0.075 to 1.5 kva are available for 220/440 volts primary to 110 volts secondary at 60 cycles. Transformers for 50-cycle operation are available in six sizes ranging from 0.150 to 1.5 kva for 208/220/380/416/440 volts primary to 110/95 volts secondary, and in 25-cycle operation in sizes from 0.150 to 0.500 kva at 220/440/550 volts primary to 110 volts secondary.

3. Equipment for the continuous, radio frequency selective induction hardening of cylindrical parts at feed rates to six inches per second. The equipment consists of three major components: an automatic loading device, a horizontal rotating scanner, and an industrial radio frequency generator.

4. A type *T* motor operating mechanism for outdoor air brake and disconnecting switches. The motor is of the torsional output type, and is available in a wide range of operating voltages.

Additional information on any of the above instruments may be obtained from Westinghouse.

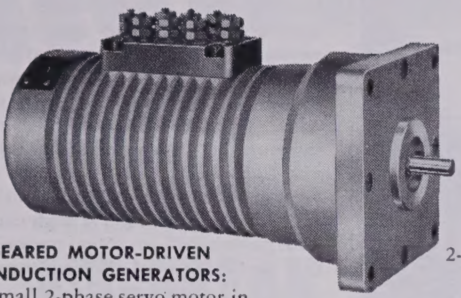
Roller-Smith Circuit Breaker. The new Roller-Smith air circuit breaker is available in 15,000 and 25,000 rms ampere interrupting rating capacity. Continuous current carrying capacity ranges from 15 to 225 amperes for the *RS-15* circuit breaker and from 36 to 600 amperes for the *RS-25* circuit breaker. Potential ratings for both are 250 volts direct current and 600 volts alternating current. The breakers were developed to protect feeder circuits and for use as main circuit breakers on medium capacity systems. Any further information may be had by writing for catalog *2550*, to Roller-Smith, Division of Reality and Industrial Corporation, Bethlehem, Pa.

Dry-Type Transformers. The Allis-Chalmers Manufacturing Company, South 70th Street, Milwaukee, Wis., has announced a new line of dry-type transformers, designed for hard service, and suitable for duty right at the load center. Built in sizes of $1^{1}/_{2}$ kva and larger, single phase; and 9 kva and larger, three phase, 60 cycle. Copies of "Allis-Chalmers Dry-Type Transformers," bulletin *61B6382A*, which describes the instruments thoroughly, are available upon request to Allis-Chalmers.

Timing Relay. The Bulletin *849* pneumatic timing relay is a new adjustable timer recently announced by Allen-Bradley Company. It is available for alternating or direct current, and utilizes a synthetic rubber bellows for controlling the tripping time. The range is adjustable from 10 cycles to 3 minutes, with an accuracy of plus or minus 10 per cent. The relay re-

(Continued on page 38A)

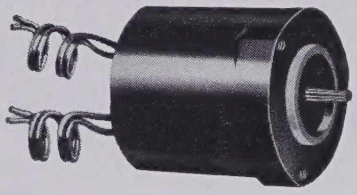
extreme precision, instant response in remote indication and control



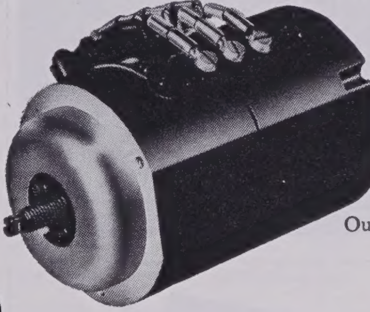
GEARED MOTOR-DRIVEN INDUCTION GENERATORS: Small 2-phase servo motor in combination with a compact gear-reducer and a low residual induction generator. Motor has high torque/inertia ratio and develops maximum torque at stall. Gear-reducer permits a maximum torque output of 25 oz. in. and is available in ratios from 5:1 to 75,000:1.

CIRCUTROL UNITS: rotary electromagnetic devices for use as control components in electronic circuits and related equipment. Single and polyphase rotor and stator windings are available in several frame sizes. Deviation from sine accuracy of resolver shown is ±0.3% of maximum output.

INDUCTION MOTORS: miniature 2-phase motors of the squirrel cage type. Designed specifically to provide fast response to applied control signals and maximum torque at zero r.p.m. Unit shown weighs 6.1 oz. and has stalled torque of 2.5 oz. in.

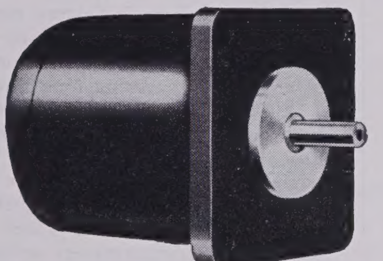


SYNCHRONOUS MOTORS: for instrumentation and other applications where variable loads must be kept in exact synchronism with a constant or variable frequency source. Synchronous power output up to 1/100 H.P.



SYNCHRONOUS DIFFERENTIAL UNITS: electro-mechanical error detectors with mechanical output for use in position or speed control servo systems. These torque-producing half-speed synchroscopes are composed of two variable frequency synchronous motors and a smoothly operating system of differential gearing.

Output: Speed $= \frac{N_1 - N_2}{2}$: Torque up to 1.0 oz. in.



TELETORQUE UNITS: precision synchros for transmitting angular movements to remote points. Accurate within ±1°. May be actuated by mechanisms that produce only 4 gm. cm. (.056 oz. in.) of torque.

ADDITIONAL SPECIAL PURPOSE AC UNITS BY KOLLSMAN

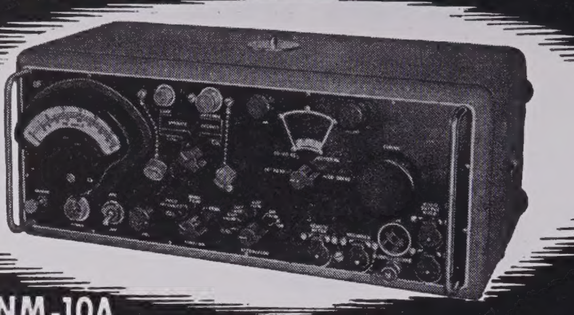
With the recent addition of new units to Kollsman's already widely diversified line, the electronics engineer will find the solution to an even greater variety of instrumentation and control problems. These lightweight, compact units offer the high degree of accuracy and positive action essential in dealing with exact quantities. They are the product of Kollsman's long experience in precision instrumentation and aircraft control — and of considerable work done in this field by Kollsman for special naval and military application. Most units are available at various voltages and frequencies. For complete information, address: Kollsman Instrument Division, Square D Company, 80-08 45th Avenue, Elmhurst, N. Y.

KOLLSMAN INSTRUMENT DIVISION

SQUARE D COMPANY

ELMHURST, NEW YORK GLENDALE, CALIFORNIA

V. L. F. !
Very Low Frequencies covered by the . . .



STODDART NM-10A
RADIO INTERFERENCE AND FIELD INTENSITY METER

- MEASURES radiated and conducted signals, including pulse or random interference.
- RANGE—14 kc to 250 kc.
- SENSITIVITY — Field strength using rod antennas one microvolt-per-meter to 2 volts-per-meter. Field strength using shielded loop antennas 10 microvolts-per-meter to 100 volts-per-meter. As a two-terminal voltmeter, either balanced or unbalanced, one microvolt to one volt.
- READS directly in microvolts and db.
- A.C. POWER SUPPLY REQUIREMENTS 105 to 125 volts or 210 to 250 volts A.C. Single phase source may be ANY FREQUENCY BETWEEN 50 CPS AND 1600 CPS. No shock hazard.
- GRAPHIC RECORDER included with versatile complement of accessories.

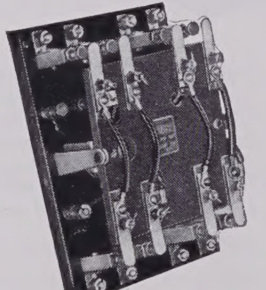
Write for complete technical data
STODDART AIRCRAFT RADIO CO.

Main office and plant:
6644 Santa Monica Blvd.
Hollywood 38, Calif.
Phone: Hillside 9294

8-247 General Motors Bldg.
Detroit 2, Michigan
Phone: Trinity 1-9260

1346 Connecticut Ave.
duPont Circle Bldg.
Washington 6, D. C.
Phone: Hudson 7313

Multi-Contact RELAYS
for Specialized Controls



featuring
Mechanical locking, no latching.
Single solenoid action with integral control contacts permitting circuit connections equivalent to a two-coil unit.
Wiping and adjustable contacts for reliable service at milliamperes of load at low voltage or at full rating.

rated at
10 and 25 amperes; AC to 550 volts; DC to 250 volts.

in three available combinations
10 amperes to 12 poles normally open and 12 poles normally closed or any combination of normally open and normally closed poles. 550 volt AC maximum.
10 amperes to 6 poles normally open and 6 poles normally closed or any combination of normally open and normally closed poles. 250 volt DC maximum.
25 amperes to 6 poles normally open and 6 poles normally closed or any combination of normally open and normally closed poles. 250 volt DC 550 volt AC maximum.

Do you require a sturdy reliable RELAY to maintain circuit control regardless of momentary interruption in control line due either to low voltage or associated relay operating time? Do you need a RELAY to provide "memory" circuits or to permit preset control operations? Utilities have found them very useful in combination for AC service on contacts, DC operating coil. Control systems needed for many machine tools, industrial machines and furnaces will find such a RELAY in this special ASCO design. And when the AC hum of a magnetically-held relay would be a nuisance, this mechanically held ASCO RELAY would be ideal.

In writing for further information, write us fully about your requirements.

AUTOMATIC TRANSFER SWITCHES • REMOTE CONTROL SWITCHES • CONTACTORS • RELAYS
We also manufacture a complete line of Solenoid Operated Valves for Automatic and Remote Control of Liquids and Gases

ASCO Electro-Magnetic CONTROLS

Automatic Switch Co.
385-F Lakeside Avenue • Orange, New Jersey

(*Continued from page 30A*)

sets instantaneously. Performance is unaffected by temperature, humidity, or vibration. Additional information on the instrument may be obtained from the Allen-Bradley Company, Milwaukee, Wis

Drive Head Ground Rod. A slotted bolt-tightened wedge makes a quickly assembled, permanent and positive connection between conductor and ground in a new drive head ground rod manufactured by the A. B. Chance Company, Centralia, Mo. Ground connection is made by inserting the conductor in the slotted plug and tightening the bolt through the plug, wedging the ground wire tightly to the rod. The rod is made of high carbon steel and galvanized to resist corrosion. Further details are available from the company

General Electric Developments. The General Electric Company has announced the following new products:

1. An improved portable oven-temperature tester, which can be used by domestic-range installation and service men to check the calibration of gas and electric oven-thermostat indications against actual oven temperatures. The instrument, which consists of a $3^1/_2$-inch square flange thermocouple thermometer mounted in a small case, is a sensitive d-c millivoltmeter, and has a scale range of zero to 650 degrees Fahrenheit and a scale length of 2.46 inches.

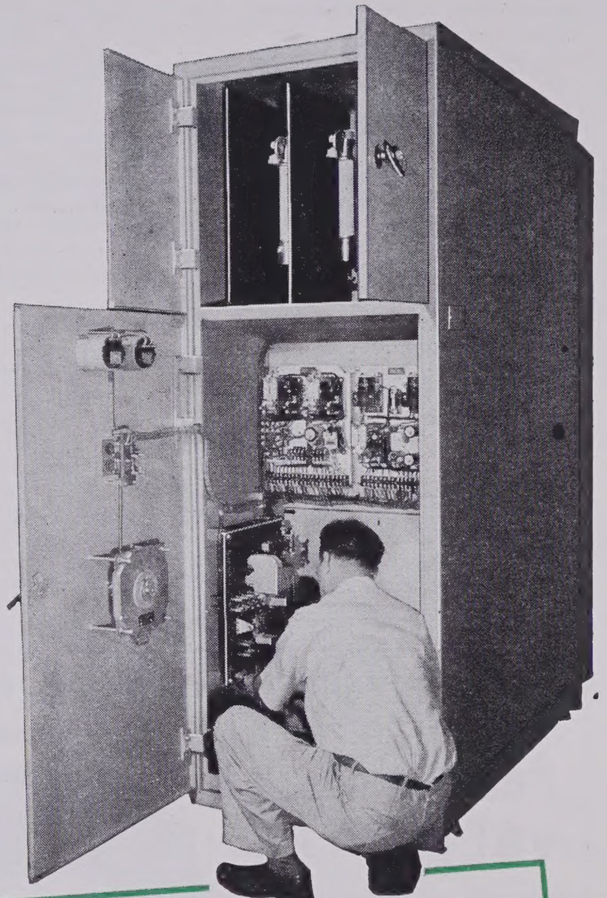
2. Temperature indicators for industrial and laboratory use, which include cold-end compensated thermocouple thermometers for measuring temperatures up to 3,000 degrees Fahrenheit and resistance thermometers for temperatures up to 300 degrees Fahrenheit. The thermocouple thermometer is available in two sizes: type *DO-71* with a $3^1/_2$-inch flange and the *DW-71* with a $2^1/_2$-inch flange. The resistance thermometers are available in two types: the *DB-15* long-scale instruments and the types *DD-6* and *DD-7* six-inch rectangular, surface– and flush-mounted instruments. Both types of indicators can be used for temperature measurement in a wide variety of applications.

3. An educational amplistat which demonstrates the self-saturating, polarity-conscious magnetic amplifier principle. The instrument operates from 115-volt, 60-cycle line, and consists of a saturable reactor and rectifiers which are mounted in one unit. This assembly is fastened to the top surface of a textolite panel which has a schematic diagram of the component parts moulded in its surface for demonstration purposes. Eighteen educational type spring terminals are supplied, and their connection with the reactor and rectifiers are indicated by the markings on the panel. Electrical engineering laboratories of educational institutions will find the amplistat useful for experiments in voltage or current regulation of small generators, investigation of motor speed control, totalizing and recording current in several independent circuits, demonstrating the principle of

(*Continued on page 48A*)

NOW! 5000V in 34"

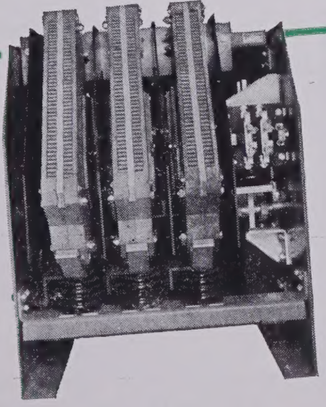
NEW SMALLER G-E LIMITAMP AIR-BREAK CONTROLLER



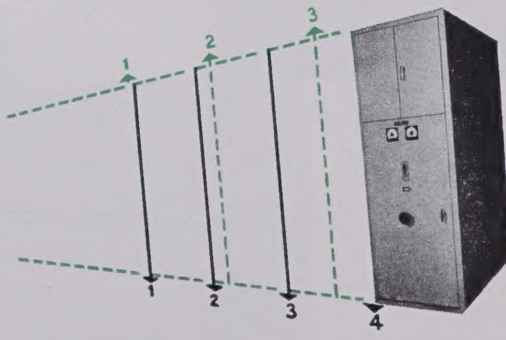
Only 34 inches wide—including enclosure—as contrasted to the previous 52, yet capable of controlling 840 more volts—that's modern design exemplified in this new high-voltage control for motors up to 1250 horsepower.

G-E developed EJ-2 fuses, providing quiet, fast-acting short-circuit protection are enclosed in a compartmented steel cabinet with the new, low-inertia air-break contactor. All the control you need for motors (even those on rapid duty cycle) is engineered, assembled, and tested in our factories to save you layout, installation, operation, and maintenance costs.

Write for more information in Bulletin GEA-5409. This includes descriptions of oil-immersed Limitamp control, reduced-voltage, two-speed, and reversing forms as well as the new full-voltage air-break controller. ***Apparatus Dept., General Electric Co., Schenectady 5, N. Y.***



MORE VOLTAGE New air-break design increases the maximum rating from 4160 to 5000 volts.



LESS SPACE Width of cabinet is reduced, so now, four air-break controllers can occupy the space formerly taken by three.

GENERAL ELECTRIC

730-12

(*Continued from page 38A*)

the amplistat, or for demonstrating the principle of d-c current transformers and saturable reactors.

4. A 265-ampere 7.5-kw aircraft energizer, which is a lightweight ground power supply suitable for medium requirements of low-voltage d-c power for aircraft, airports, and aircraft testing stations. High overload of 500 amperes for one minute, and dual range of regulated voltage at both 14 and 28.5 volts provides a wide range of application to aircraft equipment. Low voltage range of the energizer is 13-17 volts, while high voltage range is 28–35 volts. Voltage regulation is plus or minus $2^1/_2$ per cent over the entire range, and the induction motor for the energizer is a General Electric type *K* squirrel cage, 220/440 or 550 volts, 2 or 3 phase, 60-cycle. Any further details on the products listed above may be obtained from the General Electric Company, Schenectady 5, N. Y.

D-C Power Supply. A highly regulated d-c power supply, designed for any application requiring a voltage between 10 and 50 kilovolts with a maximum current requirement of two milliamperes, has been announced by the Scientific Instrument Section of the RCA Engineering Products Department. The new power supply, RCA type *EME-2*, may be used as an accelerating supply for cathode-ray tubes or for use in nucleonics and the operation of laboratory test equipment. The equipment consists of a driver unit and a rectifier unit, and is available with either positive or negative ground. Final output voltage is taken from the rectifier unit and can be continuously varied, by means of the controls on the driver unit, between 10 and 50 kilovolts. Ripple voltage is held to a maximum of five volts. A high degree of regulation is accomplished by feeding back a portion of the output voltage potential to the driver unit through a high-value resistor. This is amplified to control the grid potential on a regulator tube, which in turn controls the plate voltage of the radio frequency oscillator in the driver unit. Varying the voltage on the plate of the radio frequency oscillator controls the d-c output voltage from the rectifier unit. By this means, the output voltage is automatically maintained at the level chosen by the operator.

Further information is available by writing to RCA Victor, Division of Radio Corporation of America, Camden, N. J.

Liquid Power Fuse Mountings. Power fuse protection of 7,500- and 15,000-volt distribution transformers and substations is now available at ordinary open-type cutout prices, by means of a single insulator mounting for the S and C liquid fuse, manufactured by the S and C Electric Company, 4435 Ravenswood Avenue, Chicago 40, Ill. By recessing the end inserts in the porcelain, leakage and arcing distances have been increased to provide insulation values for the new mounting which greatly exceed National Electrical Manufacturers Association standards for cutouts, and equals NEMA standards for switch and bus insulators. The simplified mounting and liquid power fuse combinations are available in ratings of 7,500 and 15,000 volts, and with short circuit interrupting ratings of 3,900 to 8,600 amperes, rms, asymmetrical. Full information is published in Catalog Section *223*, which may be obtained from the company.

MEASUREMENTS CORPORATION

Peak-to-Peak VOLTMETER

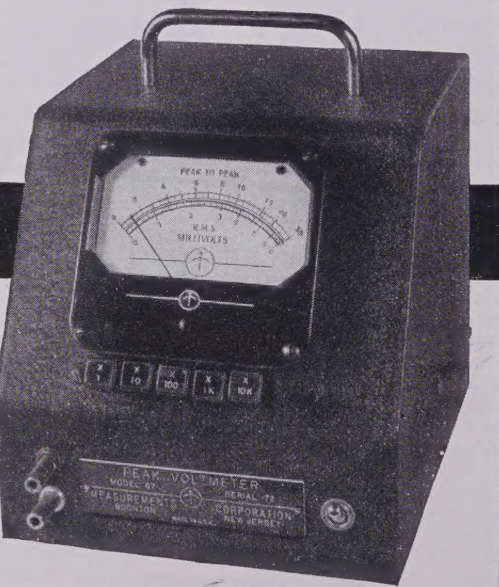
.0005—300 VOLTS

MODEL 67

Designed for accurate indication of the peak-to-peak values of symmetrical and asymmetrical waveforms, varying from low frequency square waves to pulses of less than five microseconds duration.

.0005-300 volts peak-to-peak, .0002-100 volts r. m. s. in five ranges. Semi-logarithmic, hand calibrated scales.

Provision for connection to 1500 ohm, 1 milliampere graphic recorder or milliammeter.



INPUT IMPEDANCE: 1 megohm shunted by 30 mmfd.
DIMENSIONS: Height 7½", width 7", depth 8½". Weight 8 lbs.
POWER SUPPLY: 117 volts, 50-60 cycles, 35 watts.

MEASUREMENTS CORPORATION
BOONTON NEW JERSEY

TRADE LITERATURE

Ilsco Electrical Catalog. Ilsco Copper Tube and Products, Inc., Mariemont, Cincinnati 27, Ohio, has issued a 78-page catalog on electrical lugs, connectors, and accessories, which contains technical data for use and installation, engineering information, and a compilation of the dimensions, ampere ratings, wire sizes, weights and descriptions useful to engineers and designers in the field. Copies of the manual, catalog number *50*, may be obtained by writing to the company.

"How to Improve Your Load Voltage Without Breaking the Camel's Back." Cornell-Dubilier's bulletin number *147*, "How to Improve Your Load Voltage Without Breaking the Camel's Back," describes the company's new *3KVAR* capacitor, an improved version of the original which was introduced in 1937. Copies of the bulletin are available upon request to the Cornell-Dubilier Electric Corporation, South Plainfield, N. J.

Transformer Catalog. Catalog number *49A*, published by the Audio Development Company, 2833 Thirteenth Avenue South, Minneapolis 7, Minn., describes the company's expanded line of transformers—the Quality Plus and Industrial series, and the new Yeoman line, which runs in a lower price range. The catalog may be obtained upon written request to the company.

Micro Tips. Micro Tips is published as an idea exchange of uses and ways in which to use snap-action switches in order to do jobs more efficiently, and is directed toward plant engineers, electricians, and maintenance men. Volume *1*, Number *5*, has just been published, and this and previous issues are available upon request to Micro Switch, Freeport, Ill.

Formed Fibre Wedge Selector. A sample card that permits actual tests of various sizes for correct fits, is being distributed by the Insulation Manufacturers Corporation to introduce their new Inmanco brand of formed fibre wedges. The wedges are used in rotor and stator slots of motors to hold windings securely in place. A sample of each of the nine standard Inmanco sizes is attached to a circular disc, called The Fibre Wedge Selector, which may be obtained upon request to Insulation Manu-

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